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The Use of Artificial Light and Reduction of the Daylight Period for Flowering Plants in the Greenhouse

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THE USE OF ARTIFICIAL LIGHT AND REDUCTION OF THE DAYLIGHT PERIOD FOR FLOWERING PLANTS IN THE GREENHOUSE

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The results and the discussion of the use of artificial light for greenhouse and house plants, as well as the reduction of the daylight period, are supplementary to those published in Ohio Agricultural Experiment Station Bulletin 512 (1932).

REDUCTION OF THE DAYLIGHT PERIOD THROUGH THE USE OF BLACK CLOTH

The results of tests reported in Bulletin 512 indicated that chrysanthemums under black cloth flowered from 25 to 56 days earlier than the untreated ones, when the daylight period was reduced by covering the plants from 5 P. M. to 7 A. M. This treatment caused the immediate formation of terminal buds instead of the normal development of crown buds, followed by terminal buds. The flowers so produced were equal in quality and stem length to those grown normally. Bronze and pink varieties showed a tendency to fade due to intense heat during the flowering period. It was also found that complete covering with black cloth was essential, that white cloth covering was valueless, that the use of cloth before sufficient stem length was attained induced short stems, that stopping of the treatment on pompons before buds showed color produced uneven flowering, and that duration of the light, rather than its intensity, governed the reactions secured.

The tests in 1932 and 1933 were conducted to determine the optimum number of days required to secure the most satisfactory results from daylight reduction on chrysanthemums, the possibilities of succession cropping by applying the black cloth at successive intervals, the types of cloth best adapted to the purpose, the growing of standard chrysanthemums to single and double stems to a plant, the desirability of shading chrysanthemum pot plants, the varieties most suitable, and the reduction of daylight period for pompons grown under tobacco cloth.

LENGTH OF APPLYING SHADE

Five plots of 126 plants each of pompon variety White Wings were covered with black cloth for a varying number of days. Black cloth was applied on July 15 for 14, 21, 28, and 35 days, with one plot serving as a check.

Table 1 shows that Plot 5 was the only plot which flowered uniformly. Plots 2, 3, and 4 flowered very irregularly; the time of cutting the crop varied from 16 to 34 days. The reason for this uneven flowering is attributed to the fact that the cloth was removed too soon. A crown bud is formed first when the black cloth is not allowed to remain over 35 days (Fig. 1).

TABLE 1.—Length of Application Period

Plot No.	Length of short-day treatment	First appearance of bud	Date bud showed color	Date of first cutting	Date of last cutting	Average stem length	Difference in flowering days
						In.	
1	Normal treatment	Sept. 7	Oct. 5	Oct. 13	Oct. 20	44	.....
2	14 days	Aug. 4	Sept. 27	Oct. 4	Oct. 20	32	9
3	21 days	Aug. 4	Aug. 30	Sept. 16	Oct. 20	29	27
4	28 days	Aug. 4	Aug. 30	Sept. 12	Oct. 11	30	31
5	35 days	Aug. 4	Aug. 30	Sept. 12	Sept. 23	30	31

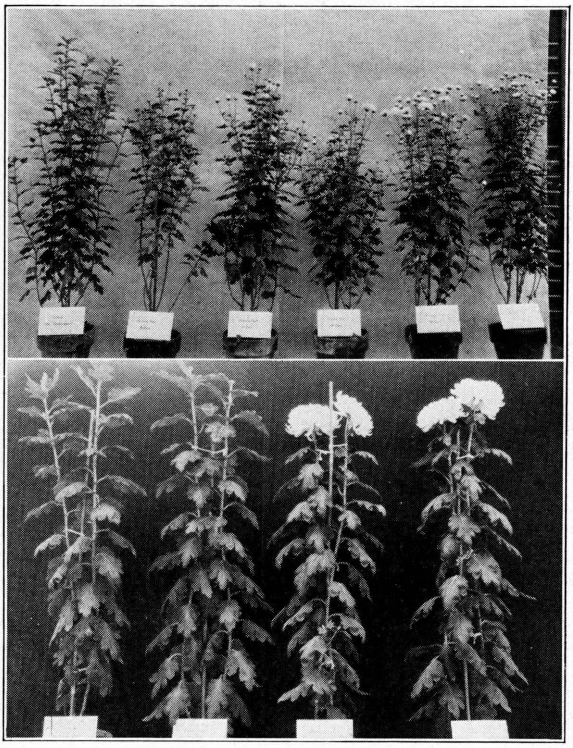

Fig. 1.—*Top*—Reduction of daylight period on variety White Wings. Left to right: No treatment, 8-day reduction, 18-day reduction, 24-day reduction, 30-day reduction, 45-day reduction. *Bottom*—Reduction of daylight period on variety Silver Sheen. Left to right: No treatment, 8-day reduction, 30-day reduction, 45-day reduction.

The plot which received 35 days of treatment produced a very uniform crop, and the entire crop was removed within 11 days after the first cutting, as compared with 7 days in the check plot. However, there was a difference of 31 days in earliness in favor of the plot receiving 35 days of reduced day length from July 15 to August 19. Flowers in Plot 4 were cut 31 days in advance of the check plot, but the crop lasted until the check plot was cut.

This same treatment of applying black cloth was carried out with the following standard varieties: Indianola, Calumet, Detroit News, and October Rose. In addition, shading the glass to reduce fading of the flowers was tried.

TABLE 2.—Length of Application Period on Indianola

Plot No.	Length of short-day treatment	Date of taking bud	Date bud showed color	Date of cutting	Average stem length	Average flower diameter	Difference in flowering days
					In.	*In.*	
1	Normal treatment	Sept. 8	Oct. 3	Oct. 17	45	6.0	.....
2	14 days	Aug. 10	Sept. 7	Sept. 18	39.5	6.0	29
3	21 days	Aug. 10	Aug. 22	Sept. 7	34	5.75	40
4	28 days	Aug. 10	Aug. 20	Sept. 2	34	5.75	45
5	35 days	Aug. 10	Aug. 22	Sept. 2	34	5.75	45

October Rose, Detroit News, and Calumet responded very similarly to Indianola. In this case the plots which were treated for 14 or 21 days flowered very irregularly. The buds on the plants in Plot 2 were crown buds. The entire plot did not flower at one time and a large number of culls resulted. No apparent difference was noted between Plots 4 and 5. The buds were beginning to break at the time the treatment was discontinued on Plot 5. The stem length was greater under normal treatment than for the treated plots. This is to be expected, and for that reason the plants that are to be covered with black cloth should be planted earlier (Fig. 2).

Fig. 2.—*Left*—Reduction of daylight period (18 days). Variety Yellow Dot—September 27. *Center*—Reduction of daylight period (28 days). Variety Yellow Dot—September 27. *Right*—Reduction of daylight period. Variety Silver Sheen—September 27. Left—30-day treatment. Right—No treatment.

Shading the glass with whitewash did not stop the fading of the bronzes and the pinks entirely but was helpful. Detroit News did not fade so much as Calumet or Indianola.

SUCCESSION CROPPING (1932)

POMPONS

A succession of bloom from the 1st of September until the 15th of October is very desirable. For that reason the application of the black cloth should be so governed as to have the crops following one another. Eleven varieties of pompons were planted 9 x 9 inches. Plot treatments were started July 15, 22, 29, and August 5. Each plot was covered from 38 to 40 days. At the time the treatment was discontinued the buds were showing color.

TABLE 3.—Succession Cropping—Cora Peck Buhl

Plot No.	Date of short-day treatment	First appearance of bud	Date bud showed color	Date of cutting	Average stem length	Difference in flowering days
					In.	
1	July 15–Aug. 22	Aug. 1	Aug. 27	Sept. 8	24	39
2	July 22–Aug. 31	Aug. 10	Sept. 2	Sept. 12	26	35
3	July 29–Sept. 7	Aug. 16	Sept. 7	Sept. 16	28	31
4	Aug. 5–Sept. 12	Aug. 22	Sept. 12	Sept. 18	28	27
5	Normal treatment	Sept. 7	Oct. 9	Oct. 17	47	.....

The results show that manipulation of the time of treatment results in variance of flowering and that one variety may be grown and flowered over a long period of time. The plants flowered very uniformly on all plots. The stem length gradually increased with successive applications. The other varieties grown in this experiment were as follows: White Wings, Iridescent, Pink Dot, Ermalinda, Rodell, Irene, Ethel, Varsity, Firebird, and Gold Lode. All varieties flowered very satisfactorily. Varieties such as Rodell and Irene flowered the early part of September in Plot 1 and in all plots were entirely cut out within 5 days after starting to flower.

Succession of cropping has an advantage in that one good variety may be treated at weekly intervals until the 15th of August, and in that way only a few varieties need be grown.

Table 4 shows the effects on eight varieties of starting treatment July 15, August 1, August 15, and September 1. The time of applying the shade was longer than usual because of the variety New York. The shade was removed when the last variety showed color.

The height of the plants when the short-day treatment was started differed with the varieties. Rodell and Uvalda (in Table 1, Plot 1) were 11 inches high July 15 but when cut on September 6 were 24 and 22 inches, respectively. The time required from date of starting treatment until cutting was 6 to 7 weeks. The earlier the shading the more the time needed for their development; for instance, the July 15 plot required 7 weeks, while the August 15 plot flowered in 6 weeks. The time varies with the temperature that prevails when the flowers mature. Extremely hot weather will hasten the development of the chrysanthemum after color of the bud is visible. All varieties in Table 4 flowered successively when treated at biweekly intervals. This method produced a steady cut of the same variety from September 6 until the normal flowering date.

TABLE 4.—Succession of Crops with Pompons

Plot No.	Variety	Height of plants at time of starting short-day treatment	Height of plants at time of stopping short-day treatment	Date of starting treatment	Date of stopping treatment	First appearance of buds	Date first bloom cut	Cutting period	Average stem length	Average production per plant, 9-ounce bunch
		In.	*In.*					*Days*	*In.*	*Bunch*
1	New York	24	34	7/15	9/5	8/ 5	9/18	14	34	0.38
	Rodell	11	22			8/ 5	9/ 6	9	24	.29
	Jewell	13	23			8/ 3	9/ 6	9	25	.38
	Nubian	16	34			8/ 7	9/ 9	9	35	.35
	Greta	12	25			8/ 5	9/ 6	9	26	.40
	Lilac	16	31			8/ 3	9/ 6	9	31	.44
	Uvalda	11	22			8/ 3	9/ 6	9	22	.30
	Irene	13	28			8/ 5	9/13	7	27	.32
	Cora Peck Buhl	14	31		9/8	8/ 8	9/16	14	31	.38
	Ethel	14	26			8/ 8	9/16	14	26.5	.40
2	New York	27	38	8/ 1	9/13	8/19	9/29	16	38	.49
	Rodell	19	31			8/18	9/16	14	32	.26
	Jewell	21	32			8/17	9/18	12	30	.59
	Nubian	24	42			8/19	9/18	12	30	.39
	Greta	17	30			8/18	9/13	5	30	.26
	Lilac	23	35			8/17	9/18	12	36	.51
	Uvalda	19	31			8/17	9/16	5	32	.37
	Irene	19	29			8/15	9/16	4	29	.23
	Cora Peck Buhl	21	31.5			8/15	9/21	9	33	.26
	Ethel	18	29			8/19	9/21	9	28.5	.39
3	New York	31	43	8/15	9/25	9/ 1	10/ 6	9	42	.49
	Rodell	20	37			8/26	9/28	9	33	.33
	Jewell	24	37			8/26	9/30	10	34	.38
	Nubian	28	42			9/ 1	10/ 2	8	45	.40
	Greta	23	37			8/26	9/27	10	35	.29
	Lilac	27	40			8/27	10/ 3	7	39	.44
	Uvalda	25	38			8/26	9/27	10	38	.27
	Irene	24	27		9/29	8/30	9/27	7	37	.23
	Cora Peck Buhl	24	36			8/30	10/ 4	8	36	.21
	Ethel	23	30			8/30	10/ 6	6	32	.38
4	New York	38	43	9/ 1	10/3	9/10	10/22	.....	43	.57
	Rodell	28	34			9/ 1	10/10	6	38	.42
	Jewell	28	33			9/ 1	10/ 9	6	36	.44
	Nubian	38	50			9/10	10/12	4	50	.32
	Greta	31	35			9/ 4	10/ 6	9	36	.45
	Lilac	33	39			9/ 1	10/13	2	42	.57
	Uvalda	31	38			9/ 4	10/ 9	6	38	.27
	Irene	31	40			9/ 4	10/ 6	9	35	.21
	Cora Peck Buhl	31	40			9/ 4	10/16	4	43	.32
	Ethel	25	30			9/ 4	10/16	4	32	.37

TABLE 5.—Succession of Crop with Standards

Plot No.	Variety	Height of plants at time of starting short-day treatment	Height of plants at time of stopping short-day treatment	Date of starting treatment	Date of stopping treatment	Date of taking bud	Date of first cutting	Cutting period	Average stem length	Average flower diameter
		In.	*In.*					*Days*	*In.*	*In.*
1	Silver Sheen	23	36	7/15	9/1	8/ 7	9/12	3	38	5.0
	Ambassador	30	48			8/ 7	9/12	3	43	5.5
	Detroit News	26	42			8/ 7	9/14	7	38	5.3
	Friendly Rival	27	45			8/ 7	9/15	17	37	5.0
	Mefo	29	48			8/ 7	9/21	11	41	6.0
	Honey Dew	25	40			8/ 7	9/15	15	38	6.0
	Rose Glory	28	45			8/ 7	9/ 1	14	45	5.0
	Indianola	30	46			8/ 7	9/ 1	14	46	5.5
2	Silver Sheen	33	42	8/1	9/4	9/ 4	9/14	6	36	4.5
	Ambassador	39	50			9/ 4	9/18	4	42	5.5
	Detroit News	33	47			9/ 5	9/26	6	48	5.0
	Friendly Rival	31	45			9/12	9/26	8	44	5.0
	Mefo	39	51			9/10	9/26	10	48	5.5
	Honey Dew	31	43			9/10	9/26	10	40	5.0
	Rose Glory	40	51			9/ 3	9/15	15	54	4.5
	Indianola	36	46			9/ 4	9/18	12	40	4.5
3	Silver Sheen	40	51	8/15	9/13	9/13	10/ 2	4	47	5.0
	Ambassador	44	53			9/13	10/ 2	6	51	5.5
	Detroit News	40	52			9/19	10/ 7	12	57	5.3
	Friendly Rival	43	54			9/20	10/14	6	61	5.8
	Mefo	48	61			9/19	10/12	7	55	5.8
	Honey Dew	37	49			9/19	10/ 7	6	54	5.5
	Rose Glory	50	61			9/13	9/22	10	52	5.0
	Indianola	45	53			9/13	9/27	16	50	4.5
4	Silver Sheen	49	54	9/1	9/13	9/15	10/12	8	60	5.5
	Ambassador	50	54			9/15	10/12	8	63	5.8
	Detroit News	50	53			9/20	10/30	4	51	6.0
	Friendly Rival	46	48			9/20	10/30	4	56	5.8
	Mefo	55	60			9/20	10/30	4	60	6.0
	Honey Dew	46	49			9/20	10/30	4	60	5.8
	Rose Glory	59	61			9/15	10/ 9	11	59	5.0
	Indianola	47	48			9/10	10/ 9	11	46	4.5

STANDARDS

Succession of crop with standards (Table 5) presents a similar condition to that reported for pompons. A uniform succession was obtained when treatment was applied July 15, August 1, August 15, and September 1. The September 1 treatment advanced the cutting date 7 to 10 days over the normal cutting period.

TYPES OF CLOTH

Table 6 represents the results obtained from the use of four different materials. The treatment was started July 1. The figures show that the rubberized material was very effective, but it was cumbersome to handle. The temperature under the rubberized cloth was much higher than under the black sateen. The three Windsor cloths numbered 375, 376, and 377 showed that the thread count is very important in reducing the light intensity most effectively for early bloom. Numbers 375 and 376 produced uniform early blooms; whereas 377 was not satisfactory. Number 375 was the most desirable.

TABLE 6.—The Effects of Darkening with Various Types of Black Cloth

Variety	Type of cloth	Thread count per square inch	Date first buds were taken	Date first buds showed color	Date first blooms cut	Cutting period	Average stem length	Average flower diameter
						Days	*In.*	*In.*
Detroit News	Rubberized	.....	7/24	8/10	9/ 4	12	36.0	6.0
	Windsor No. 375	64 x 104	7/24	8/14	9/ 4	17	35.0	5.8
	Windsor No. 376	64 x 88	7/26	8/14	9/12	13	36.0	5.5
	Windsor No. 377	68 x 72	8/ 5	9/30	10/20	10	40.0	5.5
Mrs. H. E. Kidder	Rubberized	.....	7/24	8/ 7	8/31	15	37.0	6.0
	Windsor No. 375	64 x 104	7/24	8/14	9/ 4	18	35.0	5.8
	Windsor No. 376	64 x 88	7/29	8/19	9/12	11	36.0	5.8
	Windsor No. 377	68 x 72	8/10	9/25	10/15	9	40.0	5.8
Silver Sheen	Rubberized	.....	7/24	8/ 4	8/24	14	33.0	5.5
	Windsor No. 375	64 x 104	7/24	8/ 7	8/27	13	35.0	5.8
	Windsor No. 376	64 x 88	7/24	8/11	9/12	9	34.0	5.5
	Windsor No. 377	68 x 72	8/ 5	9/20	10/ 1	9	39.0	5.5

Table 7 represents a determination of light transmission through cloths of varying density. This determination was made with a sight meter and comprises an average of several tests.

TABLE 7.—Light Intensity Under Cloth

Cloth	Thread count	Foot candles under greenhouse condition	Foot candles under cloth	Percentage of light transmitted
Windsor No. 375	64 x 104	4,360.0	1.9	0.04
Windsor No. 376	64 x 88	4,318.6	7.8	0.18
Windsor No. 377	68 x 72	4,377.0	46.8	1.07
Rubberized	.....	4,370.0	0	0

TABLE 8.—Single Versus Double Stems

Variety	Date of taking bud		Date first bud showed color		Date of first cutting		Cutting period		Average stem length		Average flower diameter	
	Single	Double	Single	Double	Single	Double	Single	Double	Single	Double	Single	Double
							Days	*Days*	*In.*	*In.*	*In.*	*In.*
Silver Sheen	7/24	7/24	8/ 7	8/ 7	8/24	8/27	8	13	30	34	6.0	5.0
Celestra	7/18	7/24	8/ 1	8/ 6	8/17	8/19	5	25	34	35	4.0	4.0
Detroit News	7/18	7/24	8/11	8/11	9/ 4	9/ 6	9	13	36	36	6.0	5.3
Friendly Rival	7/24	7/28	8/15	8/19	9/12	9/13	10	12	34	36	6.0	6.0
Mefo	7/24	7/28	8/11	8/15	9/ 4	9/12	9	13	40	44	6.0	5.8
Honey Dew	7/24	7/28	8/14	8/15	9/ 9	9/13	16	12	31	30	6.0	6.0
Ambassador	7/24	7/24	8/ 5	8/ 5	8/27	8/30	3	12	36	36	6.0	6.0
Rose Glory	7/24	7/24	8/ 3	8/ 3	8/17	8/19	2	3	34	34	5.0	5.0
Indianola	7/18	7/24	8/ 5	8/ 5	8/17	8/19	7	7	30	31	5.0	5.0
Mrs. H. E. Kidder	7/18	7/24	8/ 7	8/14	8/31	9/ 4	5	9	32	36	5.5	5.5
Golden Bronze	7/24	7/24	8/11	8/14	8/30	9/ 1	6	9	38	43	6.0	6.5
Chrysolora	7/24	7/24	8/ 7	8/ 5	8/27	8/30	8	15	36	38	5.5	4.5
Sun Glow	7/24	7/24	8/ 7	8/11	9/ 1	9/ 1	3	12	36	33	5.0	4.5
Betsy Ross	7/18	7/24	8/ 7	8/ 7	9/ 4	9/ 4	1	9	37	40	5.5	5.5
Chieftain	7/24	7/24	8/11	8/11	8/27	8/30	8	15	33	33	5.0	5.0
Smith's Early White	7/22	7/22	8/ 7	8/ 7	8/21	8/21	4	11	36	37	6.0	6.2
Citronella	7/28	7/28	8/11	8/19	9/ 9	9/13	12	6	33	33	5.5	6.0
Columbus Dispatch	7/25	7/25	8/19	8/19	9/ 9	9/13	16	6	38	42	7.0	6.0
Yellow Mefo	7/25	7/25	8/19	8/14	9/ 9	9/ 9	7	10	42	46	6.0	6.0
Reality	7/24	7/24	8/11	8/11	8/31	8/27	10	20	34	33	4.3	4.0
Oscoda	7/24	7/24	8/19	8/19	9/12	8/12	2	2	32	30	5.5	5.3
Hilda Bergen	7/24	7/24	8/ 5	8/ 5	8/27	8/30	7	14	34	36	5.0	4.5

SINGLE VERSUS DOUBLE STEMS PER PLANT

Ordinarily, growing two stems per plant is the most economical method of culture of standard chrysanthemums. To determine whether, under short-day treatment, such a practice is feasible, a number of varieties were tested. The results in Table 8 show that the single stems produced flowers a little earlier and were removed in a shorter time; however, commercially the cost of production of single stems would be out of the question.

DOUBLE USE OF CLOTH (1934)

The series of tests during the past 4 years has shown that the most satisfactory results are secured when the day is shortened by 2 hours in the afternoon and 2 hours in the morning—i. e., from 5 P. M. until 7 A. M. Further tests have shown, however, that the reduction of daylight period during the morning (just before daylight and until 9 or 10 A. M.) or during the afternoon (3 P. M. until dark) may also be used. Such findings have a practical bearing because it becomes possible to use the same cloth on double the number of plants by covering one batch in the morning and then using the same cloth on another batch of plants in the afternoon. To secure such results it is necessary to use a cloth which transmits no light (rubberized cloth is satisfactory). The cloth (64 x 104 count) ordinarily recommended may produce uneven flowering and does not give the required earliness.

Table 9 indicates the results with standard varieties. In this case rubberized cloth was used and the treatment was started July 3.

TABLE 9.—Double Use of Cloth

Variety	Date of maturity (flowering date)			
	Normal	Covered from 5 P. M. until 7 A. M.	Covered from 3 P. M. until dark	Covered from dark until 10 A. M.
Rose Glory	Oct. 15	Aug. 20	Sept. 2	Sept. 12
Mrs. H. E. Kidder	Oct. 20	Sept. 5	Sept. 15	Sept. 25
Silver Sheen	Oct. 20	Sept. 1	Sept. 8	Sept. 22
Detroit News	Oct. 25	Sept. 5	Sept. 10	Oct. 1

The results of this test show that the least time for maturity is required when the plants are covered from 5 P. M. until 7 A. M. next morning, followed by covering from 3 P. M. until dark and, finally, by covering from dark until 10 A. M. The differences secured in the last two cases may be attributed to the elimination of light of high intensity in the morning.

Table 10 shows the results with pompon chrysanthemums when black cloth (64 x 104) was used in a manner similar to that for the standard types.

These data show that the use of cloth (64 x 104) from 3 P. M. until dark and from dark until 10 A. M. does not produce as early maturity as the treatment from 5 P. M. until 7 A. M. It will also be noted that the hastening of maturity with the use of this cloth is slight in comparison with that produced by the rubberized cloth (Table 9). The lateness of maturity in this case necessitates a much longer period of covering, which increases the labor cost considerably.

TABLE 10.—Double Use of Cloth—Pompons

Variety	Date of maturity (flowering date)			
	Normal	Covered from 5 P. M. until 7 A. M.	Covered from 3 P. M. until dark	Covered from dark until 10 A. M.
Nubian	Oct. 20	Sept. 12	Oct. 10	Oct. 14
Pink Dot	Oct. 25	Sept. 15	Oct. 5	Oct. 14
Ethel	Oct. 25	Sept. 15	Oct. 5	Oct. 15
Varsity	Nov. 10	Sept. 20	Oct. 15	Oct. 25
Greta	Oct. 20	Sept. 6	Sept. 23	Oct. 1
New York	Nov. 15	Sept. 20	Oct. 14	Oct. 20
Cora Peck Buhl	Oct. 25	Sept. 20	Oct. 5	Oct. 12
Lilac	Oct. 15	Sept. 5	Sept. 23	Oct. 5
Bonnie Maid	Oct. 20	Sept. 5	Oct. 5	Oct. 10
Firebird	Oct. 25	Sept. 10	Oct. 15	Oct. 20
Uvalda	Oct. 10	Sept. 5	Sept. 22	Oct. 5

SHADING OF POT PLANTS

Pot plants during September are very scarce. Shading pot plant pompons July 15 until August 30 will produce good short-stemmed plants that will find a ready market.

REDUCTION OF DAYLIGHT PERIOD UNDER TOBACCO CLOTH

Chrysanthemums produce a very satisfactory growth in a tobacco cloth enclosure, but, due to the danger of early frosts in the fall under normal conditions, the crop may be a failure. To insure the removal of the crop before frost it becomes necessary to apply the short-day treatment to the plants. Table 11 shows the results obtained with five varieties which were covered with black cloth in the usual manner from 5 P. M. until 7 A. M. (July 8 until August 11).

TABLE 11.—Pompon Chrysanthemums Under Tobacco Cloth

Variety	Length of stem	Number of plants required to make a 9-ounce bunch
Uvalda	28	2.1
Varsity	30	2.2
Firebird	34	2.0
Rodell	27	2.4
Pink Dot	33	2.3

REDUCTION OF DAYLIGHT PERIOD UNDER BLACK CLOTH

VARIETIES

Not all varieties of chrysanthemums respond equally to the reduction of daylight period. In order to determine the best possible kinds, many were tried. Table 12 indicates the treatment and results secured.

TABLE 12.—Varieties Under Black Cloth in the Greenhouse

Pompons

Variety	Date planted	Date last pinch	First cut	Last cut	Remarks
Black cloth applied July 8—Removed August 29					
Alecia	5/13	6/ 6	9/10	.....	.....
Bokhara	5/12	6/ 3	9/ 5	9/ 5	.....
Bonnie Maid	5/13	5/29	9/ 1	9/ 3	.....
Bronze Queen	5/13	6/ 3	9/ 7	9/11	.....
Capt. Cook	5/13	6/ 3	9/ 5	.....	.....
Cora Peck Buhl	5/11	6/ 3	9/11	9/18	.....
Dotson	5/13	5/25	9/ 7	.....	.....
Ethel	5/13	5/31	9/ 9	9/16	.....
Greta	5/11	6/ 3	8/27	9/ 3	.....
Irene	5/13	5/29	9/ 3	9/ 5	.....
Jewell	5/12	5/29	9/ 6	.....	.....
Marilyn	5/12	5/29	9/ 7	.....	.....
Minong	5/13	5/29	9/ 6	9/11	.....
Nubian	5/11	6/ 3	8/28	.....	.....
Nuggets	5/11	5/31	9/10	9/18	.....
Rodell	5/11	5/31	8/27	9/ 8	.....
Roman Bronze	5/12	6/ 3	9/ 2	.....	.....
Black cloth applied July 18—Removed September 15					
Acto	5/22	6/17	9/25	9/25	Fades
Agatha	5/18	6/ 4	10/ 1	10/ 6	Satisfactory
Alecia	6/ 3	6/22	9/22	9/28	Fades
Alice	6/ 5	6/22	10/ 7	10/14	Good
Alice Howell	5/10	6/ 5	10/ 5	10/ 9	Satisfactory
Aloma	5/18	6/15	9/12	9/19	Satisfactory
Amos	5/16	6/17	9/24	9/24	Fades
Anna L. Moran	5/10	6/ 6	9/12	9/16	Satisfactory
Ariana	5/22	5/26	9/26	9/26	Fades
Arlyn	5/16	6/16	10/ 3	10/ 9	Satisfactory
Baby	5/14	6/23	10/ 3	10/ 6	Satisfactory
Benoit	5/16	6/10	9/12	9/19	Satisfactory
Blanche	5/12	6/16	9/26	10/ 3	Satisfactory
Bokhara	5/16	6/14	9/12	9/16	Satisfactory
Bonnibell	5/16	6/ 4	9/12	9/14	Satisfactory
Bonnie Maid	5/ 8	6/12	9/ 9	9/12	Fades
Bronze Doty	5/11	6/14	9/22	9/22	Not good
Bronze Queen	5/23	6/15	9/10	9/19	Good
Buckingham, Bronze	5/15	6/ 3	9/16	9/19	Satisfactory
Buckingham, Pink	5/15	6/ 3	9/16	9/19	Satisfactory
Capt. Cook	5/ 8	6/10	9/12	9/16	Good
Carrie	5/22	6/ 2	9/20	9/13	Fades
Chestnut	5/26	6/16	9/25	9/25	Satisfactory
Co-ed	5/12	6/ 6	9/25	9/25	Fades
Cora Peck Buhl	5/ 5	6/15	9/20	10/ 3	Good
Dainty Maid	5/12	6/14	9/19	9/27	Good
Dolora	5/16	6/ 4	9/21	9/23	Satisfactory
Dotson	5/15	6/ 4	9/12	9/16	Good
Edith Newberry	5/15	6/16	9/26	9/26	Fades
Elora	5/10	6/15	9/19	9/25	Good
Ermalinda	5/10	5/27	9/12	9/18	Satisfactory
Ethel	5/20	6/10	9/16	9/20	Fades
Faina	6/17	No	9/23	9/23	Satisfactory
Firebird	5/16	6/10	9/18	9/20	Satisfactory
Flora	5/17	6/15	9/20	9/25	Satisfactory
Francis Whittlesy	5/ 4	5/26	9/20	10/ 1	Satisfactory
Ginza	6/17	No	10/ 1	10/ 3	Good
Gold Finch	5/11	6/15	9/20	9/24	Satisfactory
Gold Mine	5/10	6/15	9/25	9/27	Satisfactory
Graceland	5/23	6/16	9/19	10/ 2	Satisfactory
Grenadier	5/12	6/15	9/24	9/24	Satisfactory
Greta	5/25	6/10	9/ 6	9/ 9	Satisfactory
Gretchen Piper	5/12	6/14	9/18	9/18	Satisfactory
Gypsy Girl	5/ 3	5/26	9/25	10/ 8	Satisfactory
Ida	5/15	6/ 5	9/16	9/20	Satisfactory
Irene	5/15	6/ 6	9/ 9	9/12	Good
Irene Rich	5/14	6/15	9/19	9/19	Fades
Iridescent	5/17	6/ 2	9/12	9/16	Fades

TABLE 12.—Varieties Under Black Cloth in the Greenhouse—Continued

Variety	Date planted	Date last pinch	First cut	Last cut	Remarks
Isotta	5/22	6/ 6	9/ 9	9/12	Fades
Jemima	5/12	6/14	9/18	9/18	Satisfactory
Jewell	5/ 3	6/ 5	9/11	9/16	Fades, but good
Laelia	5/20	6/ 6	9/28	10/10	Satisfactory
Leilah	5/18	6/ 5	9/ 9	9/ 9	Fades
Lilac	5/18	6/ 5	9/ 9	9/13	Satisfactory
Lillian Doty	5/12	6/15	9/19	9/19	Fades
Little Tot	5/10	5/24	9/21	9/24	Fades
Maple Leaf	5/18	6/ 3	9/26	9/26	Satisfactory
Marcella	5/12	6/16	10/ 3	10/ 7	Fades
Margo	5/18	6/16	10/ 3	10/10	Satisfactory
Margot	5/ 4	6/ 4	9/ 3	9/ 3	Not uniform
Marguerite Clark	5/15	6/15	9/19	9/24	Fades
Marilyn	5/ 5	6/ 7	9/12	9/18	Good
Mary Lennon Hall	5/11	6/15	9/18	9/26	Good
Mary Pickford	5/15	6/ 4	9/19	9/21	Satisfactory
Minong	6/ 3	6/22	9/12	9/18	Satisfactory
My Pride	5/17	6/10	9/20	9/20	Satisfactory
Nellie Kleris	5/16	6/12	9/18	9/18	Fades
New York	6/17	6/17	9/26	9/28	Good
Normandia	5/ 5	5/26	9/ 9	9/12	Satisfactory
Nubian	5/17	6/10	9/ 9	9/16	Good
Nuggets	5/ 6	6/10	9/18	9/23	Good
Ouray	5/17	6/15	9/18	9/20	Satisfactory
Pauline Wilcox	5/18	6/12	9/19	9/21	Satisfactory
Pink Dot	5/18	6/15	9/12	9/18	Good
Rodell	5/20	6/ 5	9/ 7	9/11	Good
Roman Bronze	5/ 5	6/ 7	9/12	9/16	Good
Rose Charm	5/16	6/16	9/23	9/23	Fades
Ruth Adams	5/10	6/16	9/24	9/24	Satisfactory
Ruth Cummings	6/ 3	No	9/23	9/25	Satisfactory
Sea Gull	5/12	6/16	9/21	9/26	Good
Sheila	5/20	6/15	9/21	9/23	Satisfactory
Silver Ball	5/10	5/26	9/12	9/16	Satisfactory
Silver Tips	5/16	6/16	9/20	10/ 1	Good
Snow Bird	5/17	6/ 6	10/ 3	10/ 3	Satisfactory
Source d'Or	5/16	6/14	9/21	9/25	Fades
Uvalda	5/20	6/ 7	9/12	9/16	Satisfactory
Varsity	5/22	6/ 6	10/ 1	10/ 1	Satisfactory
Wee Dot	5/15	6/28	9/25	9/25	Fades
White Doty	5/11	6/15	9/20	9/20	Satisfactory
White Wings	5/26	6/22	9/ 6	9/ 6	Satisfactory
Yellow Doty	6/17	6/17	9/20	9/23	Satisfactory
Yellow Doty	5/18	5/26	10/10	10/14	Satisfactory
Zenobia	5/ 3	5/26	9/12	9/16	Satisfactory
Zora	5/ 3	5/26	9/12	9/16	Satisfactory
Black cloth applied July 18—Removed August 26 (Disbudded)					
Adelphia	6/15	6/16	9/26	10/10	Satisfactory
Angello	5/24	6/16	9/ 5	9/12	Fades
Ball of Gold	5/22	6/16	9/26	10/10	Satisfactory
Berneita	5/23	6/16	9/23	10/ 1	Fades
Betty Rose	5/23	6/16	9/18	10/ 1	Satisfactory
Greystone	5/26	6/16	9/20	9/26	Not good
Izola	5/24	6/16	9/21	9/28	Fades
Loucella	5/23	6/17	9/21	9/29	Satisfactory
Muskoko	5/25	6/17	9/21	10/ 5	Satisfactory
Pomona	5/23	6/16	9/21	9/29	Satisfactory
Savanta	5/23	6/16	9/12	9/18	Satisfactory
Stop Light	5/26	6/17	9/27	10/16	Satisfactory
Wakanda	5/25	6/17	9/21	10/ 5	Fades
Yellow Muskoko	5/24	6/17	9/20	9/26	Satisfactory

TABLE 12.—Varieties Under Black Cloth in the Greenhouse—Continued

Standard Chrysanthemums

Variety	Date planted	Date last pinch	First cut	Last cut	Remarks
Black cloth applied July 8—Removed August 8					
Ambassador	5/ 6		8/29	9/ 1	
Celestra	5/ 5		8/20	9/ 3	
Citronella	5/ 7		9/16	9/20	
Detroit News	5/ 5		9/ 8	9/15	
Hilda Bergen	5/ 6		8/25	9/ 1	
Indianola	5/ 6		8/25	9/ 1	
Mrs. H. E. Kidder	5/ 6		9/ 8	9/10	
Pink Chief	5/ 7		8/26	9/ 1	
Reality	5/ 6		8/26	9/ 5	
Rose Glory	5/ 7		8/26	9/ 3	
Silver Sheen	5/ 6		8/29	9/ 1	
Sun Glow	5/ 6		9/ 8	9/10	
Black cloth applied July 18—Removed August 26					
Ambassador	5/18		9/12	9/18	Good
Betsy Ross	5/16		9/19	9/23	Satisfactory
Camilla	5/18		9/20	9/25	Soft
Celestra	5/18		9/ 3	9/ 9	Soft
Chas. W. Johnson	5/18		10/ 1	10/ 5	Satisfactory, late
Chieftain	5/19		9/12	9/16	Fades
Christina	5/23		9/ 9	9/16	Satisfactory
Chrysolora	5/20		9/16	9/20	Satisfactory
Citronella	5/15		9/25	10/ 4	Good
Detroit News	5/18		9/19	9/25	Good
Early Monarch	5/20		9/18	9/23	Satisfactory
Electra	5/10		9/11	9/19	Satisfactory
Floyd Gibbons	5/20		9/27	10/ 3	Satisfactory
Gold Lode	5/20		8/31	9/ 6	Satisfactory
Golden Bronze	5/20		9/21	9/25	Soft
Golden Glory	5/18		9/13	9/20	Satisfactory
Golden Glow Imp.	5/16		9/12	9/18	Not good
Golden Herald	5/15		9/11	9/16	Satisfactory
Golden Measure	5/20		9/21	9/25	Satisfactory
Golden October	6/15		9/11	9/16	Good
Golden Wave	5/15		9/12	9/18	Good
Governor Green	5/16		9/18	9/21	Satisfactory
Hilda Bergen	5/10		9/ 7	9/12	Good
Indianola	5/10		9/ 3	9/12	Good
Justrite	5/18		9/ 7	9/12	Satisfactory
J. W. Prince	5/19		9/ 9	9/16	Fades, but good
Keystone	5/20		9/20	9/28	Satisfactory
Lustre	5/20		9/ 3	9/ 5	Satisfactory
Marigold	5/18		9/23	10/ 5	Satisfactory
McNiece	5/20		9/20	9/27	Satisfactory
Mrs. H. E. Kidder	5/20		9/16	9/25	Shatters
Oconto	5/18		9/18	9/18	Satisfactory
October Rose	5/17		9/12	9/18	Fades
Old Rose	5/15		9/16	9/20	Satisfactory
Pink Chief	5/15		9/ 6	9/ 9	Good
Pink Delight	5/15		9/20	10/ 5	Good
Pink Reliance	5/18		9/ 9	9/12	Satisfactory
Quaker Maid	5/20		9/ 3	9/ 7	Satisfactory
Reality	5/22		9/ 5	9/ 9	Good
Richmond	5/19		9/ 9	9/16	Satisfactory
Rose Chochard	5/26		9/ 9	9/16	Good, but short
Rose Glory	5/22		9/ 5	9/ 9	Good
Rose Marie	5/20		9/ 3	9/ 9	Fades
Rose Perfection	5/20		9/18	9/23	Fades
Silver Dawn	5/15		9/12	9/18	Good

TABLE 12.—Varieties Under Black Cloth in the Greenhouse—Concluded

Variety	Date planted	Date last pinch	First cut	Last cut	Remarks
Silver Sheen	5/20	.....	9/ 6	9/12	Good
Smith's Advance	5/18	.....	9/ 9	9/ 9	Not good
Smith's Early White	5/21	.....	9/ 3	9/ 9	Soft
Smith's Superlative	5/20	.....	9/20	9/25	Satisfactory
Snow White	5/21	.....	9/20	10/ 5	Good
Sun Glow	5/18	.....	9/18	9/23	Good
The Peer	5/20	.....	9/21	9/24	Satisfactory
Tints of Gold	5/20	.....	9/11	9/14	Satisfactory
White Chieftain	5/16	.....	9/ 9	9/16	Good
White Chieftain	5/10	.....	9/12	9/18	Good
Woolf's Pink	5/10	.....	9/16	9/19	Satisfactory
Yellow Gold	5/14	.....	9/12	9/16	Satisfactory
Yellow Streak	5/17	.....	9/16	9/20	Satisfactory

The varieties most strongly recommended for the treatment under cloth are:

POMPONS		STANDARDS	
Capt. Cook	Lilac	Ambassador	Mefo
Cora Peck Buhl	Minong	Betsy Ross	Mrs. H. E. Kidder
Ermalinda	Nubian	Citronella	Muskoko
Ethel	Nuggets	Detroit News	Pink Chieftain
Firebird	Pink Dot	Friendly Rival	Pink Chief
Greta	Rodell	Golden Bronze	Richmond
Irene	Uvalda	Hilda Bergen	Rose Glory
Jewell	Varsity	Honeydew	Silver Sheen
Leilah	White Wings	White Chieftain	Sun Glow
Bonnie Maid	Bokhara		
Yellow Dot			

GENERAL RECOMMENDATIONS

1. Plant early, not later than June 1.
2. Use black shades covering tops and sides (64 x 104 thread count or light-weight rubberized cloth).
3. Cover from 5 P. M. until 7 A. M.
4. Treatment started July 15 and followed in weekly succession will result in a succession of bloom.
5. Remove cloth on pompons after buds show color; this is usually from 35 to 40 days after treatment starts. (Extreme heat during the treatment will increase the time of application.)
6. Standards should be treated for 30 to 35 days.
7. The early and midseason varieties should be used and only those that have been tried sufficiently to warrant their use.
8. Treated late varieties will flower with midseason varieties grown under normal treatment.
9. To obtain the crop during the latter part of September or early in October start treatment August 15.
10. Pompons grown under tobacco cloth and covered with black cloth from 5 P. M. until 7 A. M. produce very satisfactory growth and deeper colors than when grown in the greenhouse.
11. Standards grown under tobacco cloth may be damaged by rains in the fall; therefore, the practice is subject to heavy losses. If provisions are made to protect the flowers by means of sash, the practice is feasible.

12. To save cloth, it may be used from 3 P. M. until darkness and then shifted to another bench and the plants covered until 10 A. M. the next morning. Only cloth which eliminates the light entirely is suitable for this purpose. (Rubberized cloth was very satisfactory.)

REDUCTION OF DAYLIGHT PERIOD ON ASTERS

Asters under cloth may be brought into bloom earlier by using black cloth in the same manner as the chrysanthemums. The results obtained in 1934 are shown in Table 13.

CONCLUSIONS

1. Early shading of asters decreases the length of flower stem. Shading June 20, June 27, and July 4 showed a successive increase in stem length from the late shading over the early shading for all varieties tested. The average increase in stem length of the check over the June 20 shading for all varieties was 7.6 inches.

2. The later varieties—Crego Deep Pink, American Branching Azure Blue, Ball's Deep Rose, Royal White, and Royal Shell Pink—showed a decrease in number of flowers per plant for the late shading. The average decrease in number of flowers per plant for the above varieties between the June 20 shading and the check was two and eight-tenths per plant. There was apparently very little influence from shading on the number of flowers per plant of the early varieties.

3. Late-flowering varieties showed a greater response to shading than the earlier varieties. The variety Royal Purple gave the first cut on July 6 regardless of when the shading began, while American Branching Azure Blue gave the first cut on July 15 when shaded June 20 and on July 28 when shaded July 4.

4. There was a slight increase in diameter of flower resulting from the late shading over the early shading.

5. Shading should begin about 8 weeks after planting; that is, asters planted May 18 should be shaded July 1 to 4 to get the best results as to size and number of flowers, combined with a reasonably early cut. For most of the early to medium early varieties, shading in late June gives the first cut around July 11 to 15, shading July 1 to 4 gives the first cut from the middle to late July; whereas the normal cutting date is from late July to early August.

ADDITIONAL LIGHT

The summary of the work done with additional illumination for flowering plants in the greenhouse in 1930 and 1931 is as follows:

1. Four hours of increased daily illumination from 6 P. M. to 10 P. M. from 50- to 100-watt clear glass, nitrogen filled, tungsten filament, Mazda lamps produced earliness of bloom in such potted plants as *Calceolaria hybrida*, *Cineraria multiflora*, and *Primula obconica*.

2. *Cyclamen persicum*, *Pelargonium zonale* (Geranium), *Asparagus sprengeri*, and *Asparagus plumosus* showed increased size under the increased daylight period.

TABLE 13.—Reduction of Daylight Period on Asters—Cloth House, 1934

Variety	Date planted	Plants per plot	Date shaded	Plants wilted	Date first cut	Date last cut	First to last cut	Flowers cut	Average stem length	Average diameter	Average flowers per plant
		No.		*No.*			*Days*	*No.*	*In.*	*In.*	*No.*
Royal Purple	5/18	21	6/20	.....	7/ 6	7/19	14	268	10.0	2.0	13.0
	5/18	21	6/27	.....	7/ 6	7/23	18	350	12.5	2.6	16.6
	5/18	21	7/ 4	.....	7/ 6	8/ 1	27	233	14.8	2.3	11.1
	5/18	21	Check	.....	7/ 6	8/ 8	33	300	16.6	2.3	14.3
Imbricated Rose (Pompon)	5/18	21	6/20	3	7/ 6	7/23	18	350	9.8	1.3	19.4
	5/18	21	6/27	15	7/11	8/ 1	22	118	11.1	1.1	19.6
	5/18	21	7/ 4	.....	7/11	8/ 1	22	400	13.0	1.3	19.0
	5/18	21	Check	2	7/11	8/ 8	29	330	13.6	1.5	17.0
Royal Shell Pink	5/18	21	6/20	.....	7/15	8/ 3	20	330	14.0	2.6	15.7
	5/18	21	6/27	1	7/19	8/ 3	16	303	16.0	2.5	15.0
	5/18	21	7/ 4	.....	7/19	8/ 8	21	243	15.8	2.7	11.5
	5/18	21	Check	.....	7/26	8/14	20	184	21.7	3.3	9.0
Royal White	5/18	21	6/20	1	7/19	8/ 3	16	233	14.0	2.4	11.6
	5/18	21	6/27	.....	7/19	8/ 3	16	234	16.2	2.3	11.1
	5/18	21	7/ 4	1	7/26	8/ 8	14	180	17.2	2.5	9.0
	5/18	21	Check	.....	8/ 1	8/17	17	165	22.0	2.7	8.0
Ball's Deep Rose	5/18	21	6/20	1	7/15	7/23	9	210	15.0	2.5	10.5
	5/18	21	6/27	4	7/19	7/30	12	171	18.2	2.3	10.0
	5/18	21	7/ 4	.....	7/26	8/ 3	9	169	19.0	2.5	8.0
	5/18	21	Check	.....	7/28	8/11	15	173	25.0	2.9	8.2
American Branching Azure Blue	5/18	28	6/20	.....	7/15	8/ 8	25	237	17.3	2.4	8.4
	5/18	21	6/27	.....	7/15	8/ 8	25	209	20.4	2.5	10.0
	5/18	28	7/ 4	2	7/28	8/14	18	179	21.3	2.7	7.0
	5/18	28	Check	.....	8/ 1	8/17	17	176	28.0	3.0	6.3
Crego Deep Pink	5/18	28	6/20	1	7/15	7/30	16	287	16.0	3.0	10.6
	5/18	21	6/27	1	7/23	7/30	7	160	17.1	2.7	9.0
	5/18	28	7/ 4	1	7/23	8/ 8	16	195	21.0	3.0	7.2
	5/18	28	Check	.....	7/28	8/14	18	153	23.2	3.3	5.5

3. Bulbous plants showed little or no response to this increased illumination, with the exception of *Lilium longiflorum* and *Iris tingitana.* In the case of lilies, earliness was secured; whereas the Iris responded by increasing the percentage of flowering.

4. The following annuals showed a striking earliness of bloom when subjected to 4 hours of increased daylight: *Antirrhinum majus* (Snapdragon), *Centaurea cyanus, Centaurea imperialis, Chrysanthemum coronarium, Chrysanthemum segetum, Coreopsis tinctoria, Cynoglossum amabile, Delphinium ajacis, Didiscus caerulea, Iberis umbellata, Gaillardia lorenziana, Gypsophila elegans, Leptosyne maritima, Matricaria capensis* (Feverfew), *Mathiola incana* (Stocks), *Salpiglossis sinuata, Scabiosa atropurpurea,* and *Schizanthus pinnatus.*

5. In the same manner a number of early-flowering herbaceous perennials responded to the treatment. They were *Achillea millifolium, Chrysanthemum maximum* (Shasta Daisy), *Coreopsis lanceolata, Gaillardia grandiflora,* and *Viola tricolor.*

6. The Boston Yellow Daisy, under the same treatment, produced earlier, larger flowers on longer stems and in greater profusion.

7. *Centaurea cyanus* produced the greatest number of flowers at an early date when subjected to a 60-day treatment with 100-watt lamps for an additional 4-hour period.

8. Additional illumination of low intensity during cloudy weather failed to bring about results commensurate with the cost involved.

9. Low-intensity supplementary illumination had a marked effect on the flowering of long-day plants. In some instances the growth was slightly weaker than that produced under normal light conditions; however, the flowers produced were marketable.

10. Temperature variations were very small in the lighted plots as compared with the control plots.

RESULTS OF TESTS IN 1932-1934

During 1932 and 1933 the work at Wooster[1] and Columbus[2] has dealt with intensity of light, various periods of application, the time of application, the use of frosted versus clear lamps, the efficiency of reflectors, and the value of additional light for house plants (Fig. 3).

NEON LIGHT

With the introduction of neon light for lighting purposes it was inevitable that some tests be attempted with this source of light on plants. A summary of the work done by J. W. M. Roodenburg[3] of Holland thus becomes of interest.

His experiments in plant irradiation carried out during the last 2 years have dealt chiefly with the intensity of neon light which is required in practice.

[1]The tests at Wooster were run by G. R. Mann, in cooperation with the Central Ohio Light & Power Co.

[2]The tests at Columbus were run in cooperation with the General Electric Co. of Cleveland.

[3]Roodenburg, J. W. M. 1933-1934. L'irradiation des plantes avec la lumiere au neon. Elektrizitate-verwertung, No. 10, 8c.

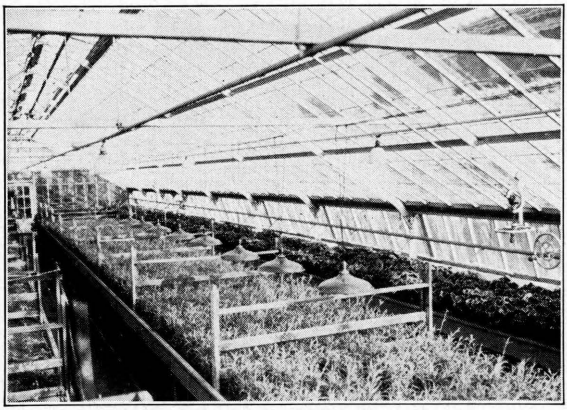

Fig. 3.—Additional light installation using porcelain lined reflectors

Previous tests showed that neon light was more suitable than any other kind of light for greenhouses. However, in order to use this light economically it was important to know what its intensity should be in order to improve the growth of the various species of plants. The cost of irradiation will depend to a large extent on the surface area that can be treated with a given source of light. When lower intensities of illumination are sufficient, it will be possible to irradiate a large surface area with one source.

In the winter of 1930-1931 an illumination averaging 60 foot-candles of neon light—this being a considerably lower illumination than that formerly employed—was tried for the sake of information on a series of plants of widely divergent species. The blossoming of a number of them was thereby greatly improved, partly through more rapid opening-out of blossoms that had already been formed (e. g., in the case of Cineraria) and partly through development of new blossoms, as was very distinctly shown by Star of Bethlehem *(Campanula isophylla)*. The *Primula malacoides* bloomed earlier and more richly. Geranium, on the other hand, showed only a slight difference in bloom.

With a view to more accurate investigation of the amount of light required, further experiments were conducted without daylight, using ordinary electric lamps at first and afterwards neon light in various doses. With an irradiation period of 12 hours it was found that the plants thus examined required 100 foot-candles of electric lamp light for fair development of their leaves. This particularly applies to cucumber and tomato plants, which develop but little at lower intensities of illumination. At exceedingly low intensities (12½ foot-candles) most plants showed a longer stagnation in growth and finally perished. Great stamina was shown by Coleus seed plants, which remained in good condition under the smallest intensity until the end of the experiment.

On pure neon light an intensity of 40 foot-candles was found to be enough for leaf development of cucumbers and tomatoes. In the case of tomatoes, 20 foot-candles proved insufficient; whereas, with cucumbers, an increasing intensity of illumination resulted in an increasing size of leaf. Fairly rapid development was obtained in this case with 80 foot-candles.

During the season 1931-1932 the results of various intensities of neon light were investigated in the greenhouse specially built for illumination experiments. The observations referred chiefly to intensities of 50 and 100 foot-candles. Here, again, it was plainly demonstrated that the effect of the illumination depended upon the species of plant irradiated; for instance, cucumber plants grew far more rapidly under 100 foot-candles of neon light than under 50. On the other hand, the total yield of cucumbers was greatest in the case of the plants with low illumination, although the plants under higher illumination bore the first fruits. In both cases the irradiation gave a considerable increase in crop, with an average increase of 19.6 per cent.

The cinerarias bloomed with approximately equal rapidity under both intensities—namely, 4 weeks earlier than the non-irradiated specimens.

Although the tomato plants developed more strongly under neon light, especially at maximum intensity, it has not yet been possible to prevent the formation of yellow spots between the nerves of the leaves. Both the strongly and the weakly illuminated plants showed this phenomenon in the same degree. Low temperatures improved matters to some extent but did not overcome this difficulty entirely.

Star of Bethlehem bloomed even without neon light under the conditions given. However, the irradiated specimens bloomed a fortnight earlier and bore 61 per cent more blossoms. As already remarked, the formation of blossoms can be promoted under fairly low intensities.

In the case of Lathyrus, somewhat more blossoms were obtained at only 50 foot-candles, but a higher intensity would probably have given more successful results.

Conspicuous was the result obtained with irradiated gloxinias, which bloomed earlier and more richly although irradiated only at the commencement of cultivation; the result was most favorable under the maximum intensity of 80 foot-candles. These plants bloomed a week earlier and gave 30 to 37 per cent more blossoms than the non-irradiated specimens.

From these experiments the general conclusion can be drawn that most greenhouse plants, when irradiated for 8 hours daily, require an illumination of at least 50 foot-candles of neon light. Lower intensities of illumination will as a rule have only little effect. Above 50 foot-candles the beneficial effect increases rapidly with the intensity, as is shown by the growth of young cucumber plants. An exception is the blossoming of Cineraria. On the other hand, for some plants a much higher intensity (about 100 foot-candles) is preferable—for instance, with Lathyrus.

For horticulture it is also important to know that neon light can promote not only leaf development but also the formation of flowers, as was demonstrated with Star of Bethlehem and gloxinias.

TESTS MADE AT THE OHIO STATE UNIVERSITY WITH SUPPLEMENTARY ILLUMINATION FROM MAZDA, MERCURY, AND NEON LAMPS ON GREENHOUSE PLANTS

The purpose of this test was to determine whether or not neon or mercury vapor lamps were more efficient than the Mazda lamps in shortening the period until bloom on a variety of annuals.

The test was conducted on four plots with an equal number of plants in each plot.

Plot 1—Check
Plot 2—Mazda, two 225-watt clear glass Mazda lamps
Plot 3—Neon, 450 watts
Plot 4—Mercury vapor, 450 watts

The lamps were placed 3 feet above the top of the pots, directly over the center of the bench. Light impervious curtains served to separate the plots. The lamps were turned on at 5:30 P. M. and off at 9:30 P. M. The following morning the curtains were raised to give maximum daylight to the plants.

Table 14 indicates the annuals grown. In every case except the annual Chrysanthemum Evening Star, there is (a) greater flower production under Mazda lamps than under either neon or mercury; (b) the time of flowering under Mazda lamps is from 0 to 41 days earlier; and (c) the Mazda plot produced from 15, in case of Leptosyne, to 148, in case of *Viola tricolor*, more flowers than the check.

In every case, plants grown under the Mazda lamps had longer stem length. The growth was somewhat more succulent, but the quality of the flowers was not reduced. The color of the foliage under all lighted plots was somewhat paler than that under check. However, the color of the flowers seemed about the same in all cases.

The plants under mercury grew more slowly than those under Mazda or neon but not so slowly as those in the check. The foliage on the plants under the mercury lamp showed spotting of yellowing in some cases.

Calceolaria hybrida variety *multiflora nana* was also tested under the various lamps. The test was started December 19, 1934. The time of flowering was as follows:

		Days earlier than check
Mazda	March 7, 1935	38
Neon	March 25, 1935	20
Mercury	March 30, 1935	15
Check	April 14, 1935	.....

Table 14 indicates that the plants under a Mazda light flowered 18 days earlier than those under neon and 23 days earlier than those under mercury.

The results of this test indicate that Mazda lamps are superior to either neon or mercury lamps not only in producing earliness of bloom but also in greater flower production, stem length, and diameter.

INTENSITY OF LIGHT AND DATE OF APPLICATION

STOCKS

Previous experiments with stocks showed that they flowered earlier when exposed to relatively low intensities. In 1932 and 1933 experiments were conducted to determine the proper intensity at which the stock plant responds and also the best date for applying the artificial light.

Artificial light was applied to prolong the daylight period. In early fall the plants were illuminated from 6 P. M. to 10 P. M. After November 12 the time was changed to 5 P. M. until 10 P. M. This variation in the number of hours of additional illumination over the entire period produced a day length of 14 to 15 hours.

TABLE 14.—Effect of Mazda, Neon, and Mercury Vapor Lamps on a Variety of Annuals

	Check					Mazda					Neon					Mercury				
	Date first cut	Date last cut	No.	Av. stem length	Av. diameter	Date first cut	Date last cut	No.	Av. stem length	Av. diameter	Date first cut	Date last cut	No.	Av. stem length	Av. diameter	Date first cut	Date last cut	No.	Av. stem length	Av. diameter
				In.	*In.*				*In.*	*In.*				*In.*	*In.*				*In.*	*In.*
Pansy	3/6	4/24	44	4.3	1.8	2/13	4/24	192	4.7	1.9	2/13	4/24	126	3.4	1.3	2/13	4/24	92	4.4	1.5
Tagetes patula Leibs	2/13	4/24	67	6.4	1.8	2/13	4/24	122	9.3	1.9	2/25	4/24	89	7.1	1.9	2/13	4/24	118	6.8	2.0
Didiscus caerulea	4/5	4/24	78	11.7	2.3	3/6	4/24	164	9.6	1.9	3/18	4/24	147	9.6	1.9	3/18	4/24	116	8.0	2.0
Leptosyne maritima	2/28	4/24	71	12.8	2.0	2/19	4/24	86	9.6	1.3	2/19	4/24	41	7.8	1.3	2/19	4/24	22	8.4	1.3
Chrysanthemum Evening Star	4/1	4/24	46	10.5	2.7	2/7	4/24	102	16.7	2.5	2/7	4/24	91	13.7	2.3	3/18	4/24	73	15.1	2.2
Chrysanthemum Morning Star	4/5	4/24	51	10.7	1.9	2/7	4/24	115	13.4	2.5	2/9	4/24	122	12.8	2.4	3/18	4/24	57	13.0	2.4
Chrysanthemum North Star	4/11	4/24	36	2.0	1.9	3/30	4/24	71	22.5	2.5	3/30	4/24	58	18.9	2.3	4/5	4/24	31	19.8	2.2
Chrysanthemum Burridgeanum	4/11	4/24	27	20.0	2.3	3/30	4/24	46	17.7	2.3	3/30	4/24	33	17.5	2.2	4/5	4/24	35	17.8	2.0
Chrysanthemum Eclipse	4/15	4/24	25	14.0	1.7	3/30	4/24	39	21.5	2.3	3/30	4/24	34	20.4	2.3	4/11	4/24	34	14.8	2.2

Scabiosa not in flower under any treatment (4-24-35).

Standard incandescent tungsten lamps mounted in RLM Dome reflectors were used on the plots that received additional illumination. Each lamp covered an area of 15 square feet of bench space. The distance from the lamp to the tip of the plant was 15 inches. The lamps were raised from time to time so as to keep a uniform height at all times. The foot-candle intensity was taken at the tip of the plant just below the lamp. Electric time clocks automatically controlled the duration of light.

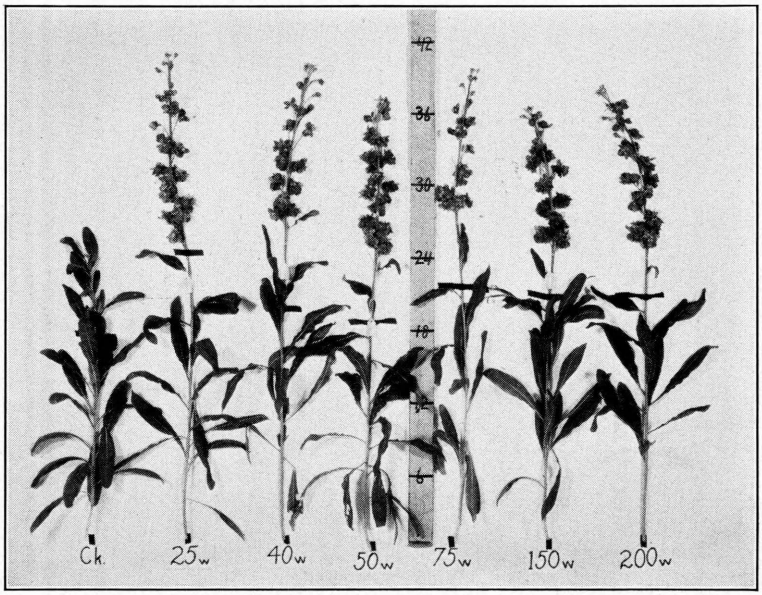

Fig. 4.—Effect of additional light of varying intensities on stocks

TABLE 15.—Effect of Adding Artificial Light at Various Stages of Development of Stocks

Variety Lilac Lavender

Mazda lamp wattage	Date of application	Date of flowering	K. W. H. per plant
150 watts	Oct. 14	Dec. 25	1.08
150 watts	Oct. 29	Dec. 28	0.90
150 watts	Nov. 14	Jan. 4	0.73
75 watts	Oct. 14	Dec. 30	0.54
75 watts	Oct. 29	Jan. 4	0.45
75 watts	Nov. 14	Jan. 6	0.37
Check	.....	Jan. 20	.....

Seed was sown August 16 and the plants were set in the bench September 27, 4 x 8 inches.

The results indicate comparatively little difference in results from early applications over the later ones. If planted September 27, stocks came in bloom for Christmas when light was applied 3 weeks after planting. The application started 4 weeks later resulted in flowers 10 days later.

TABLE 16.—Effect of Additional Light of Various Intensities on Stocks

Variety Lilac Lavender

Mazda lamp wattage	Foot candles at tip of plant	No. of plants	Average stem length	Weight per plant				Date of flowering	K. W. H. per plant
				Double		Single			
				Fresh	Dry	Fresh	Dry		
			In.	*Gm.*	*Gm.*	*Gm.*	*Gm.*		
Check (1)..	.....	59	31	67.2	8.0	38.2	4.5	Feb. 7	.....
25 watts..	1.5 to 22	60	37	68.9	7.9	47.4	6.0	Jan. 15	0.12
40 watts..	3.5 to 44	60	37	72.1	8.1	32.5	7.7	Jan. 14	0.19
60 watts..	5.5 to 90	60	37	84.8	8.7	54.3	5.9	Jan. 14	0.29
75 watts..	7.0 to 160	60	37	84.4	9.2	50.4	6.0	Jan. 14	0.36
100 watts..	16.5 to 250	60	37	77.1	9.0	45.3	5.4	Jan. 14	0.48
150 watts..	18.0 to 300	59	37	76.1	8.6	42.2	5.0	Jan. 14	0.72
Check (2)..	.....	58	30	49.8	6.8	35.5	4.5	Feb. 7	.....

A series of light intensities varying from 1.5 to 300 foot-candles, produced by lamps of 25 to 150 watts, was used as indicated in Table 16. The seed was sown August 31, the plants were benched October 17, and additional illumination was started on October 27 (Fig. 5).

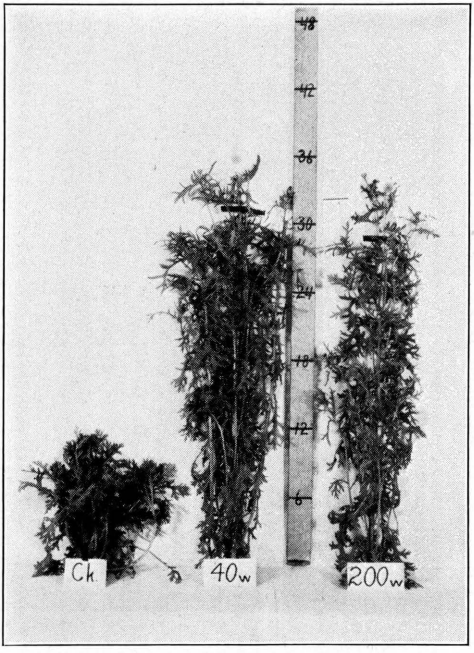

Fig. 5.—Effect of additional illumination on *Chrysanthemum segetum*—Morning Star. February 15

The results indicated that low-wattage lamps (25 to 40) with intensities from 1.5 to 44 foot-candles[4] may be substituted for comparatively high-wattage lamps (100-150) producing from 16.5 to 300 foot-candles without reducing the efficiency and yet with a lessening of the cost. The intensity was not uniform for each plant, as plants near the edge received as low as 1.5 foot-candles. Large-wattage lamps, such as 500- or 1000-watt, are not as effective for greenhouse use as reported by several workers. The average greenhouse bench is 3 to 5 feet in width, and by raising these large-wattage lamps 4 feet high considerable light would be lost through not being reflected upon the plants. Even if all the light were reflected upon the bench, this would be a more costly operation than using 40-watt lamps with suitable reflectors.

The average fresh and dry weight is comparatively similar in all cases, showing that the low-intensity plots produced plants as large and heavy as the higher intensity plots.

The value of the increased temperature resulting from the use of artificial illumination has been suggested as an important factor in the increased growth secured. Table 17 shows that the temperature rises with the approach to the lighted lamp, but it should be noted that the plant is not closer than 10 inches to the lamp at any time; therefore, the factor of temperature cannot be considered. The results in Table 17 were secured from numerous readings.

TABLE 17.—Temperature Readings at Various Distances from Lamps of Various Wattages

Distance from lamp	150-watt lamp	100-watt lamp	75-watt lamp	60-watt lamp	40-watt lamp	25-watt lamp	Check
	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*
4 inches	63.0	62.5	60.0	61.0	59.5	58.0	55.5
10 inches	54.5	54.5	54.5	54.5	54.0	53.5	53.0
16 inches	53.5	53.0	53.5	52.5	52.5	53.0	53.0
22 inches	52.0	52.5	53.0	52.0	52.0	53.0	53.0

CALCEOLARIA MULTIFLORA NANA

Previous tests showed that Calceolaria showed a striking response to additional light in earliness of flowering. A test was made to determine the most economic intensity for securing the desired results. On December 20, 1933, six plots with 20 plants to a plot were arranged under electric light using two lamps for each plot. The additional light was given from 5 P. M. until 10 P. M. each day. The plots tested were illuminated as follows:

1. 25-watt lamps
2. 40-watt lamps
3. 75-watt lamps
4. 100-watt lamps
5. 150-watt lamps
6. Check (no additional light)

On February 13 flower spikes became visible in all lighted plots. On February 26 all lighted plots showed color and the plants were fully matured by March 10. The check plot flowered April 7 (Fig. 6 Upper).

Calceolaria Rosackers Brilliance, being red in color, was supplied with additional light from 100-watt lamps (5 to 10 P. M.) beginning November 17, in an attempt to produce flowering specimens for Valentine's Day sales. The

[4]This variation is due to the varying intensities from the center of the plot to the outer edges.

application continued until February 1, and by February 15 the plants were in full bloom. The ordinary time for the flowering of this variety is between May 1 and May 30.

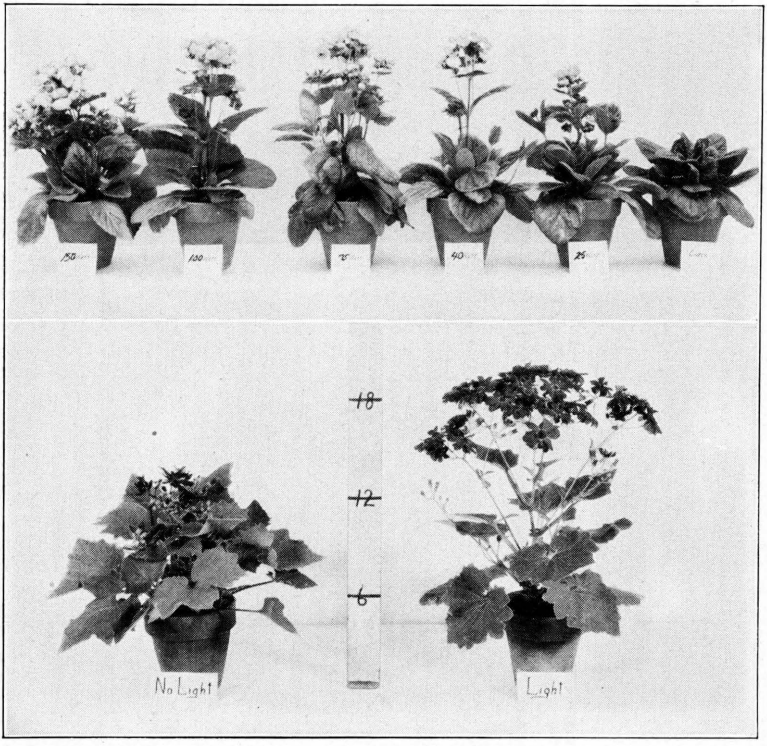

Fig. 6.—*Top—Calceolaria multiflora nana.* Effect of additional illumination on maturity. Left to right—150 watt, 100 watt, 75 watt, 40 watt, 25 watt, and check. *Bottom*—Effect of additional illumination on Cineraria. Left—No treatment. Right —24 days of additional light. February 19.

SWEET PEAS

Previous results by several workers had indicated that additional light was useful for the growth of sweet peas and that it was particularly desirable from the standpoint of bud drop elimination. To check these results tests were made at Wooster for 2 years.

1932 test.—Seed was sown September 6 and additional light was applied November 29, using 100-watt lamps spaced 6 feet apart and 30 inches above the vines. The first flowers were cut November 29 from the lighted plots and December 4 on the unlighted.

The results show little significant difference in production, although there is greater stem length with additional light and longer growth of the vines.

TABLE 18.—Effect of Light on Sweet Peas

Variety	Total flowers cut No.	Average stem length In.	Average flowers on stem No.	Height of vines when light was applied	Height of vines on Feb. 6
With additional light					
Ball's Orange	3140	10.5	2.0	4 ft. 6 in.	11 ft. 7 in.
Mrs. Hoover	2990	12.1	2.2	5 ft. 3 in.	12 ft. 4 in.
White Harmony	3410	10.3	2.4	4 ft. 9 in.	11 ft.
Jeanne Mamitch	3275	11.4	2.2	5 ft. 4 in.	11 ft. 3 in.
Without additional light					
Ball's Orange	3280	8.1	2.0	4 ft. 6 in.	8 ft. 7 in.
Mrs. Hoover	2812	9.9	2.1	5 ft. 1 in.	9 ft.
White Harmony	3275	9.1	2.1	5 ft. 1 in.	9 ft. 1 in.
Jeanne Mamitch	3330	9.5	2.4	5 ft.	8 ft. 9 in.

1933 test.—Seed was sown October 25 and the first flowers were cut under light January 27 and in the check plot February 6.

TABLE 19.—Effect of Additional Light on Sweet Peas

Plot	Treatment	Variety	Total flowers	Stem length
			No.	*In.*
1	40-watt lamp to each 4 feet of row	Mrs. Hoover	589	11.0
		Jeanne Mamitch	502	10.0
2	75-watt lamp to each 4 feet of row	Mrs. Hoover	563	10.5
		Jeanne Mamitch	519	10.0
3	150-watt lamp to each 4 feet of row	Mrs. Hoover	611	11.0
		Jeanne Mamitch	540	10.0
4	Check (no additional illumination)	Mrs. Hoover	1473	8.5
		Jeanne Mamitch	1390	8.2

These data indicate that there was no appreciable difference in production and stem length between the plots treated with lamps varying in intensity from 40 watts to 150 watts. The check plot showed a very decided increase in production but an appreciable difference in stem length. The quality of flowers judged by the number of florets per stem showed no significant difference in any plots. The amount of bud drop was insignificant in all cases. Based on these results the conclusion is reached that the response of sweet peas to additional light is not such as to warrant the practice.

CINERARIA MULTIFLORA

To study the effect of light on Cineraria, 36 plants were given additional light from 75-watt lamps placed 44 inches from the top of the plants and emitting 22 foot-candles of light. The plants were selected from a large number to secure uniform height and number of leaves. Eighteen plants were used as checks. Additional illumination was applied from January 26 to February 19. Those under light were in full bloom February 19, while the check matured March 14, 23 days later. The average height of lighted plants was

21 inches, while those in the check plot averaged 16 inches. Where earliness of bloom is desired, the use of additional light on Cineraria is of value (Fig. 6 Lower).

EFFICIENCY OF LAMPS

It is known that single, large lamps are more efficient in light distribution than a series of smaller lamps emitting the same number of foot-candles. However, because of the fact that some light rays are lost from large lamps due to their greater spread when placed over greenhouse benches, former recommendations were made to use the smaller lamps. To test the efficiency of lamps of varying wattage a series of tests was made at Wooster. In all cases the additional light application was started December 15 and was used from 5 P. M. to 9 P. M. each day until the flowers were ready to cut. Each plot was 7 x 12 feet.

TABLE 20.—Efficiency of Lamps

Plot	Plant	Flowers per plant	Average stem length	Date of flowering	Days earlier than check
		No.	*In.*		*No.*
Plot 1 Six 25-watt lamps spaced 4 ft. apart and 30 in. from the plants. Average foot-candles—7.	*Chrysanthemum segetum*, var. Morning Star	43.2	22.0	2/22	41
	Chrysanthemum frutescens, var. Boston Yellow	21.2	17.2	2/17	15
	Didiscus caerulea	37.0	22.4	3/23	40
	Clarkia elegans	.....	.....	2/20	35
	Stocks Ruby	1.0	40.0	2/15	23
	Stocks Ball's White	1.0	41.0	2/26	19
	Matricaria capensis	18.2	16.1	3/ 3	70
Plot 2 Eight 50-watt lamps spaced 3 ft. apart and 36 in. from plants. Average foot-candles—18.	*Chrysanthemum segetum*, var. Morning Star	40.0	17.2	2/17	46
	Chrysanthemum frutescens, var. Boston Yellow	19.0	19.0	2/13	19
	Didiscus caerulea	32.2	17.0	3/20	43
	Clarkia elegans	.....	.....	2/23	32
	Stocks Ruby	1.0	40.0	2/15	23
	Stocks Ball's White	1.0	40.0	2/26	19
	Matricaria capensis	16.0	15.2	3/ 1	63
Plot 3 Two 200-watt lamps spaced 7 ft. apart and 72 in. from plants. Average foot-candles—20.	*Chrysanthemum segetum*, var. Morning Star	44.0	19.4	2/19	44
	Chrysanthemum frutescens, var. Boston Yellow	16.0	18.6	2/17	15
	Didiscus caerulea	34.6	23.0	3/24	39
	Clarkia elegans	.....	.....	2/19	36
	Stocks Ruby	1.0	39.0	2/12	26
	Stocks Ball's White	1.0	41.0	2/27	18
	Matricaria capensis	14.4	13.0	3/ 1	63
Plot 4 Check	*Chrysanthemum segetum*, var. Morning Star	41.0	17.6	4/ 4	.....
	Chrysanthemum frutescens, var. Boston Yellow	20.0	12.2	3/ 4	.....
	Didiscus caerulea	31.2	19.0	5/ 2	.....
	Clarkia elegans	.....	.....	3/27	.....
	Stocks Ruby	1.0	32.0	3/10	.....
	Stocks Ball's White	1.0	34.0	3/17	.....
	Matricaria capensis	16.2	10.8	5/12	.....

The results of this test indicate no significant differences in date of flowering, production, or length of stem. All the illuminated plots flowered much earlier than the check. It will be noted, however, that similar results were obtained through the use of six 25-watt lamps emitting 7 foot-candles as were secured with two 200-watt lamps emitting 20 foot-candles and thus using almost three times as much electricity.

These data show that, in the cases of the plants tried, the lower intensities produced just as satisfactory results as the higher and at a very considerable reduction of electricity. The differences in flowering time, production, and length of stem are not significant, while the amount of electricity used varied from 13 foot-candles to 43.

TIME OF DAY

The possibility of using electric current at the lowest load suggested that additional light be supplied from 2 A. M. to 7 A. M. instead of using it from 5 P. M. until 10 P. M. To ascertain the effect a number of plants (listed in Table 21) were grown in benches to which additional illumination was given in two sets—one from 5 P. M. to 10 P. M. and the other from 2 A. M. to 7 A. M. The former is listed in Table 22 as evening illumination, the latter as morning illumination. One-hundred-watt lamps were used in the tests.

TABLE 21.—Effect of Variation in Intensity

Plot	Plant	Flowers per plant	Average stem length	Date of flowering	Days earlier than check
		No.	*In.*		*No.*
Plot 1 Six 40-watt lamps spaced 4 ft. apart and 36 in. from plants. Average foot-candles—13.	*Chrysanthemum segetum*, var. Morning Star	41.5	17.1	2/20	39
	Chrysanthemum frutescens, var. Boston Yellow	16.0	19.6	2/15	20
	Didiscus caerulea	32.6	20.0	3/25	36
	Clarkia elegans	.....	.....	2/24	28
	Stocks Ruby	1.0	40.4	2/19	22
	Stocks Ball's White	1.0	42.6	2/27	22
	Matricaria capensis	16.2	14.2	3/ 1	61
Plot 2 Six 75-watt lamps spaced 4 ft. apart and 44 ft. from plants. Average foot-candles—22.	*Chrysanthemum segetum*, var. Morning Star	38.0	19.0	2/20	39
	Chrysanthemum frutescens, var. Boston Yellow	18.0	18.0	2/16	19
	Didiscus caerulea	31.0	17.0	3/21	40
	Clarkia elegans	.....	.....	2/20	32
	Stocks Ruby	1.0	38.0	2/14	27
	Stocks Ball's White	1.0	40.2	2/27	22
	Matricaria capensis	17.0	12.0	3/ 1	61
Plot 3 Six 150-watt lamps spaced 4 ft. apart and 62 in. from plants. Average foot-candles—43.	*Chrysanthemum segetum*, var. Morning Star	44.0	18.2	2/18	41
	Chrysanthemum frutescens, var. Boston Yellow	19.0	18.2	2/12	23
	Didiscus caerulea	38.0	22.0	3/24	37
	Clarkia elegans	.....	.....	2/20	32
	Stocks Ruby	1.0	39.2	2/18	23
	Stocks Ball's White	1.0	42.2	2/27	22
	Matricaria capensis	19.0	14.2	3/ 1	61
Plot 4 Check	*Chrysanthemum segetum*, var. Morning Star	42.0	16.0	4/ 1	.....
	Chrysanthemum frutescens, var. Boston Yellow	17.0	11.1	3/ 7	.....
	Didiscus caerulea	34.0	21.1	5/ 1	.....
	Clarkia elegans	.....	.....	3/24	.....
	Stocks Ruby	1.0	.....	3/13	.....
	Stocks Ball's White	1.0	.....	3/21	.....
	Matricaria capensis	17.0	9.0	5/10	.....

The results of this test indicate that in practically all instances morning illumination is as satisfactory as evening illumination and in the case of several varieties of Chrysanthemum, larkspur, and Scabiosa there is actually a difference in earliness favoring the morning application. If it is possible to secure cheaper rates when off the "peak load", the morning illumination is suggested for the crops tried.

TABLE 22.—Effect of Morning and Evening Illumination

Variety	Date of flowering		
	Check	Morning illumination	Evening illumination
Aster			
Crego Deep Rose	Failed to flower	4/ 3	4/21
Crego Shell Pink		4/ 3	4/21
Centaurea			
americana white	Failed to flower	5/ 5	5/10
imperialis alba	4/ 4	3/30	3/ 9
imperialis lavender	4/ 4	3/23	3/21
Chrysanthemum			
Burridgeanum	4/26	2/21	3/ 9
Northern Star	3/23	2/21	3/ 9
W. E. Gladstone	3/24	2/21	3/ 9
The Sultan	4/15	3/ 1	3/ 9
Dunnetti Double Scarlet	4/26	3/ 9	3/23
frutescens	4/ 4	2/ 2	2/ 2
frutescens Boston Yellow	3/ 9	1/12	1/12
Feverfew	5/30	4/11	4/12
Leptosyne	2/11	1/ 5	1/19
Larkspur			
Carmine King	5/ 3	3/23	3/28
Daintiness	5/10	3/23	4/10
Blue Spire	5/ 3	3/23	4/10
Scabiosa loveliness	5/30	4/11	5/10
Venidium decurrens calendulaceum	3/ 9	1/21	1/21

Similar tests were run with stocks and asters, varying at the same time the number of hours of application, intensities, and the use of the ultraviolet CX lamps.

The seed for this test was sown August 15 and the plants were benched September 25. Additional lighting was started October 24 and continued until January 3. No significant differences were noted in the time of flowering between the morning- and evening-lighted plots. The same was true of the number of hours of illumination. Where high intensities were used somewhat heavier growth resulted, but this was not sufficient to compensate for the greater consumption of current. With evening illumination, the cutting period was reduced. The column indicating foot-candles shows the variation in intensity from the margin of the plot to the center under each lamp. This variation failed measurably to show greater growth in the center of the plots. Based on the results with stocks, the recommendation for the use of morning light, together with a reduction of light application from 5 to 3 hours, still holds. The use of alternating light and ultraviolet light is not warranted.

TABLE 23.—Morning Versus Evening Illumination of Stocks

Plots	First appearance of color	Date of first cutting	Average height	Foot-candles
			In.	
Plot 1 Evening, 4 hours, alternated every 5 sec., 40-watt lamp.	12/27	1/ 9	33	3.5 to 44
Plot 2 Evening, 250 CX lamp, 4 hours	12/18	1/ 5	33	41.0 to 100
Plot 3 Evening, 200-watt lamp, 4 hours	12/18	1/ 5	33	20.0 to 100
Plot 4 Evening, 40-watt lamp, 4 hours	12/27	1/ 5	32	3.5 to 44
Plot 5 Morning, 250 CX lamp, 4 hours	12/25	1/ 5	33	41.0 to 100
Plot 6 Morning, 200-watt lamp, 4 hours	12/25	1/ 5	34	20.0 to 100
Plot 7 Morning, 40-watt lamp, 4 hours	12/25	1/ 5	31	3.5 to 44
Plot 8 Check	12/31	1/18	31	.....
Plot 9 Morning, 40-watt lamp, 6 hours	12/18	1/ 5	34	3.5 to 44
Plot 10 Morning, 40-watt lamp, 5 hours	12/24	1/ 5	32	3.5 to 44
Plot 11 Morning, 40-watt lamp, 3 hours	12/25	1/ 5	30	3.5 to 44
Plot 12 Evening, 40-watt lamp, 5 hours	12/20	1/ 5	32	3.5 to 44
Plot 13 Evening, 40-watt lamp, 6 hours	12/15	1/ 5	32	3.5 to 44
Plot 14 Evening, 40-watt lamp, 3 hours	12/24	1/ 5	32	3.5 to 44

The same test was repeated with stock seed sown December 1 and the plants benched February 10.

The results secured were similar to those shown in Table 23.

To determine the effect of morning and evening illumination on asters, as well as to note the effect of intensity and the number of hours of added illumination, several varieties were benched in October. The illumination was started November 1 and continued until February 1.

The data show much variation of the different varieties in response to additional light. Variety Astermum showed the greatest production with 100-watt lamps used for 4 hours in the morning. The stem length was only slightly exceeded by the plot where 250-watt CX lamps were used. Royal Azure Blue showed little difference in all plots. Queen of the Market also showed greatest production where the 100-watt morning illumination was used. The differences in stem length were not significant. California Giant Sunshine, Ball's White, and American Branching showed no significant differences. As a result of this test it may be concluded that high intensity, long hours of illumination, and ultraviolet light are not necessary for the winter flowering of asters. The actual purpose of the additional light for asters is not earliness but the elongation of stems to make the cut flowers salable.

TABLE 24.—Morning Versus Evening Illumination of Stocks

Plot No.	Date of first cutting	Average height	Foot-candles
		In.	
Plot 1 Evening, 4 hours, alternated every 5 sec., 40-watt lamp	4/17	29	3.5 to 44
Plot 2 Evening, 250 CX lamp, 4 hours	4/12	33	41.0 to 100
Plot 3 Evening, 200-watt lamp, 4 hours.....	4/13	31.5	20.0 to 100
Plot 4 Evening, 40-watt lamp, 4 hours.....	4/17	29.5	3.5 to 44
Plot 5 Morning, 250 CX lamp, 4 hours	4/13	31.5	41.0 to 100
Plot 6 Morning, 200-watt lamp, 4 hours.....	4/14	29.0	20.0 to 100
Plot 7 Morning, 40-watt lamp, 4 hours.....	4/17	29	3.5 to 44
Plot 8 Check	4/23	26	.....
Plot 9 Morning, 40-watt lamp, 6 hours.....	4/16	29	3.5 to 44
Plot 10 Morning, 40-watt lamp, 5 hours.....	4/17	27	3.5 to 44
Plot 11 Morning, 40-watt lamp, 3 hours.....	4/16	28	3.5 to 44
Plot 12 Evening, 40-watt lamp, 5 hours.....	4/14	29.5	3.5 to 44
Plot 13 Evening, 40-watt lamp, 6 hours.....	4/13	32	3.5 to 44
Plot 14 Evening, 40-watt lamp, 3 hours.....	4/17	28.5	3.5 to 44

FROSTED VERSUS CLEAR GLASS LAMPS

Tests were conducted to determine whether any differences in growth occurred when frosted or clear glass lamps of the same wattage were used. The only differences noted were those of stem lengths, which were slightly greater with clear glass lamps. No differences were observed in the time of flowering.

ADDITIONAL LIGHT FOR POT PLANTS

In addition to the Calceolaria and Cineraria other pot plants respond favorably to additional light (100-watt lamps for 5 hours each day) by producing early bloom. Among those tried were Nemesia—25 days difference; Schizanthus—30 days difference; *Chrysanthemum frutescens* (Marguerite)—35 days difference; and Boston Yellow Daisy—30 days difference.

GENERAL RECOMMENDATIONS FOR ADDITIONAL LIGHT IN THE GREENHOUSE

1. Additional light should be applied from 5 P. M. to 10 P. M. or from 2 A. M. to 7 A. M. during fall and winter.

2. Low-wattage lamps (25 to 40) suspended 2 feet above individual benches (4-5 feet wide) and spaced 4 feet apart are sufficient for most plants responding to the additional light.

TABLE 25.—Morning Versus Evening Illumination on Asters

Plot No.	Astermum			Royal Azure Blue			Queen of the Market Dark Blue			California Giant Sunshine			Ball's White			American Branching Azure Blue		
	Av. per plant	Av. length	Av. diameter	Av. per plant	Av. length	Av. diameter	Av. per plant	Av. length	Av. diameter	Av. per plant	Av. length	Av. diameter	Av. per plant	Av. length	Av. diameter	Av. per plant	Av. length	Av. diameter
	No.	*In.*	*In.*	*No.*	*In.*	*In.*	*No.*	*In.*	*In.*	*No.*	*In.*	*In.*	*No.*	*In.*	*In.*	*No.*	*In.*	*In.*
Plot 1 Evening, 4 hours, 150 watts	3.5	8.6	2.4	6.7	10.8	2.3	5.4	10.4	2.2	7.6	12.3	3.3	4.7	7.6	2.5	6.1	12.6	2.5
Plot 2 Morning, 4 hours, 100 watts	11.2	11.8	2.6	6.8	14.4	2.6	10.5	10.2	1.7	6.3	15.0	3.5	4.8	7.7	2.8	6.5	15.2	2.8
Plot 3 Check	4.5	5.6	2.2	6.9	6.1	1.9	4.7	1.2	0.4	7.0	6.0	1.4	4.7	2.6	2.2	8.4	7.0	2.2
Plot 4 Morning, 4 hours, 200 watts	9.6	7.4	2.3	8.1	10.7	2.8	4.9	10.1	1.9	6.2	13.8	3.6	4.6	6.6	2.7	8.0	11.1	2.6
Plot 5 Morning, 4 hours, 250 CX	5.7	12.2	2.2	7.2	15.2	2.7	6.6	11.8	2.4	7.6	13.3	3.7	6.1	8.4	2.8	8.4	13.1	2.5
Plot 6 Morning, 4 hours, 150 watts	9.4	10.1	2.7	7.0	13.3	2.5	6.3	12.9	2.2	6.3	12.6	3.3	5.0	6.9	2.5	6.8	11.8	2.8
Plot 7 Check	3.6	3.5	1.0	7.7	5.9	2.0	6.0	7.1	2.0	6.8	6.6	2.5	3.7	2.2	2.1	5.6	9.1	2.2
Plot 8 Evening, 5 hours, 150 watts	6.5	8.3	2.4	4.0	14.2	2.6	5.5	10.5	2.2	6.3	12.6	3.4	4.6	8.1	2.3	7.0	13.5	2.5
Plot 9 Evening, 6 hours, 150 watts	6.1	7.6	1.7	7.5	13.3	2.4	4.8	13.1	2.0	5.3	11.9	2.9	2.5	10.2	2.7	5.1	13.7	2.4

3. Higher wattage lamps are more advantageous when the entire greenhouse is to be illuminated. (See recommendations on Pages 38-40).

4. RLM Dome reflectors are the most satisfactory. (Aluminum pie tins of similar size and depth are almost as efficient and much cheaper.)

5. Ultraviolet lamps are more costly to install and operate without compensating differences in growth or earliness.

6. Slight differences in time of flowering of stocks occur when added illumination is given 3 to 5 weeks after planting.

7. The following plants respond well to additional illumination:

CUT FLOWERS		POT PLANTS
Feverfew	Annual Chrysanthemums	*Lilium longiflorum*
Stocks	Salpiglossis	Calceolaria
Scabiosa	Pansy	Cineraria
Schizanthus	Boston Yellow Daisy	Nemesia
Didiscus	Larkspur	Marguerite
Shasta Daisy	Gypsophila	
Coreopsis	Achillea	
Leptosyne	Gaillardia	
Centaurea cyanus	*Centaurea imperialis*	
Nemesia	*Centaurea suaveolens*	

PRACTICAL CONSIDERATIONS

In order to avoid costly mistakes in wiring and to make sure of the use of efficient reflectors and the most economical methods of obtaining the least necessary illumination, the following discussion is presented by L. C. Porter, Research Laboratories of the General Electric Company, Cleveland.

LIGHTING DETAILS AND COSTS

The Mazda lamp converts electrical energy purchased from the lighting company at various rates per kilowatt hour; i. e., per 1000 watts of energy per hour depending upon the amount consumed and various other factors. For greenhouse work rates usually run from 2 to 5 cents per kilowatt hour, although they may be as low as 1 cent or as high as 10 cents. It is obvious that lamps should be selected which will convert purchased energy into light as efficiently as possible.

The cost of lighting is composed principally of two factors: one the price paid for the lamp and the other the cost of the current consumed. Table 26 shows the cost per hour of operating lamps of various sizes at different current

TABLE 26.—Operating Cost per Hour

Kilowatt hour rate for current	Wattage of lamps and list price						
	40-watt	60-watt	100-watt	200-watt	300-watt	500-watt	1000-watt
	20¢	20¢	25¢	80¢	$1.25	$2.00	$4.00
	Cents	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*
2 cents.....	0.0010	0.0014	0.0023	0.0048	0.0073	0.0120	0.0240
4 cents.....	.0018	.0026	.0043	.0088	.0133	.0220	.0440
6 cents.....	.0026	.0038	.0063	.0128	.0193	.0320	.0640
8 cents.....	.0034	.0050	.0083	.0168	.0253	.0420	.0840
10 cents.....	.0042	.0062	.0103	.0208	.0313	.0520	.1040
12 cents.....	.0050	.0074	.0123	.0248	.0373	.0620	.1240

rates. The lamp prices given are present list prices and all lamps are based on a 1000-hour average life. Individual lamps may vary somewhat above and below this average.

In general, the greater the wattage of the lamp the higher its efficiency. The efficiency of a lamp is rated in terms of the number of lumens of light it will emit per watt of electricity consumed. Table 27 shows this relation for the lamps most commonly used for plant growth.

TABLE 27.—Efficiency of Lamps

Size lamp	Initial lumens	Efficiency	Hours life
		Lumens per watt	
40-watt	428	10.7	1000
60-watt	738	12.3	1000
100-watt	1490	14.9	1000
200-watt	3360	16.8	1000
300-watt	5430	18.0	1000
500-watt	9700	19.4	1000
1000-watt	20400	20.4	1000

From Table 27 it can be seen that by using 1000-watt lamps one would obtain almost twice as much light for every watt of electricity purchased as from 40-watt lamps. It has also been shown that the higher the efficiency of the lamp, the closer the color of the emitted light approaches daylight and the better is its effect on plant growth. Thus, for that reason also it is desirable to use as high wattage lamps as practical.

Carrying operating cost calculations a step farther, we see from the lumen table that forty-eight 40-watt lamps would be required to emit as much light as a single 1000-watt lamp. The former would cost $9.60; whereas the latter would cost only $4.00. Forty-eight 40-watt lamps would consume 1920 watts of current; whereas the same amount of light may be obtained from a single 1000-watt lamp. From this we can see that the cost per lumen hour of light decreases materially as we go to the higher wattage lamps. Table 28 gives this figure for the various lamps at different current rates.

TABLE 28.—Operating Cost per Lumen Hour

Kilowatt hour rate for current	Wattage of lamps and initial lumen output						
	40-watt 428 lms.	60-watt 738 lms.	100-watt 1490 lms.	300-watt 3360 lms.	300-watt 5430 lms.	500-watt 9700 lms.	1000-watt 20400 lms.
2 cents	$.0000023	$.0000019	$.0000015	$.0000014	$.0000013	$.0000012	$.0000011
4 cents	.0000042	.0000036	.0000029	.0000026	.0000025	.0000023	.0000021
6 cents	.0000062	.0000057	.0000042	.0000038	.0000035	.0000033	.0000031
8 cents	.0000080	.0000068	.0000056	.0000050	.0000046	.0000043	.0000041
10 cents	.0000098	.0000084	.0000069	.0000062	.0000058	.0000054	.0000051
12 cents	.0000117	.0000100	.0000083	.0000074	.0000069	.0000064	.0000061

REFLECTORS

Since plants normally grow towards a light source it is generally advisable to locate lamps above the plants. In order to deliver as much of the light emitted by the lamp onto the plant as is practical, the lamp should be equipped with a reflector to collect as much of the light as practical and redirect it

down onto the plants. If no reflectors are used approximately half of the light is emitted above the horizontal and a lot of it off to the side. It is doubtful if 10 per cent of the total light generated by a bare lamp hung 3 feet above the plants in a typical greenhouse bench would fall on the plants. If the lamp were equipped with an efficient reflector so designed as to confine the spread of the light to the area occupied by the plants, perhaps as much as 60 per cent of the generated light would reach the plants.

Reflectors are available that distribute the light over a wide angle, a medium angle, or a narrow angle. Reflectors should be selected which will cover the area it is desired to light with as little waste as possible. If the units are mounted low, a wide angle or extensive distribution is usually best; whereas with high mounting an intensive or, possibly under certain conditions, even a concentrating distribution is best.

The kind of reflector to use depends largely upon the results desired. It is quite a common practice to use cheap, tin, cone-shaped reflectors in the greenhouses. Often these are simply painted on the inner surface. This paint soon discolors, cracks, or flakes off and the efficiency of the reflector is greatly lowered. We not infrequently see 100-watt or larger wattage lamps used in reflectors designed for a 40-watt or 60-watt lamp. Where this is done, much of the light is being wasted. The lamp sticking down below the edge of the reflector sends considerable of its light off to the sides where it is of no value

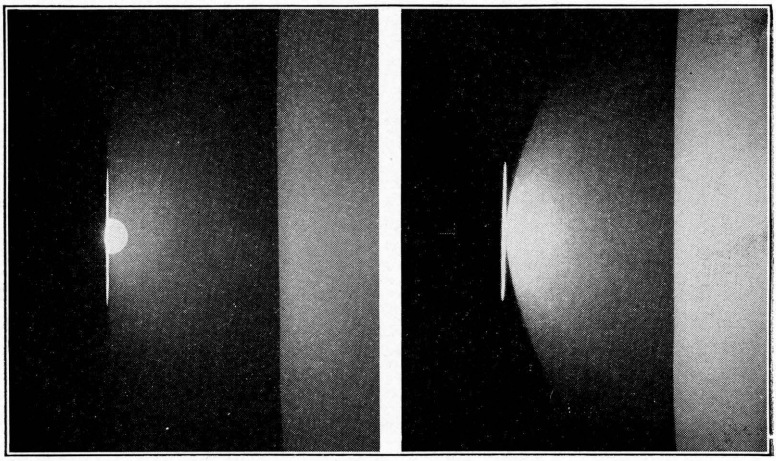

Fig. 7.—*Left*—Distribution of light with a lamp too large for the reflector. *Right*—Distribution of light with proper size of lamp in RLM Dome reflector

to the plants. It pays to select a high grade reflector of correct size for the lamp with which it is to be used. Porcelain enameled steel reflectors, known as RLM Domes, are generally the ones best suited to greenhouse conditions. These are rugged porcelain enameled steel reflectors designed to concentrate the light in the angles below the horizontal and give a practically even distribution over an angle up to 45 or 60 degrees from the vertical. In order to obtain fairly uniform lighting, the RLM Domes should generally be spaced approximately one and one-half times their mounting height—i. e., if they are located 2 feet above the plants, they should be on 3-foot centers (Figs. 7 and 8).

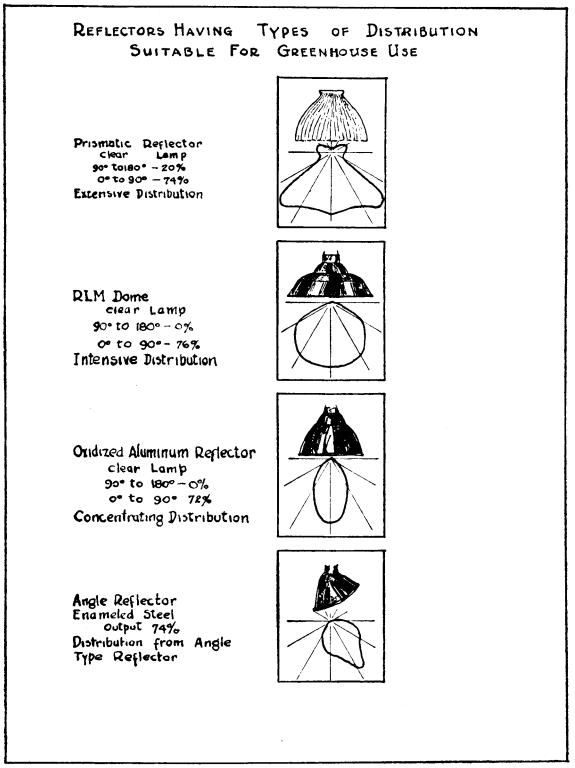

Fig. 8

There are reflectors which have a more concentrating distribution than the RLM Dome reflectors. These are useful where it is desired to use large lamps and mount them high above the plants. Oxidized aluminum reflectors, such as Ivanhoe No. 1064, are suitable for the purpose.

There are a few conditions where it may be desirable to have light delivered at an angle, such, for example, as along a row of sweet peas. RLM reflectors hung directly above them would not light them as efficiently as would a row of enameled steel angle reflectors along each side.

RECOMMENDATIONS

The following recommendations are based on a maximum of approximately 15 foot-candles and a minimum of 5. We have neglected the side benches since it appears to be more practicable to use the benches located in the center of the greenhouses for the plant forcing. If, however, it is desired to extend the illumination over the side benches, the data given for the various widths of individual benches may be used and will provide the same level of illumination over the side benches as that given for the center section.

14-FOOT GREENHOUSE

For lighting the center section of the 14-foot greenhouse it is recommended that one row of outlets be installed on the center line and mounted 5 feet above the bench. These units should be located on 7-foot centers and equipped with one 100-watt, inside-frosted Mazda lamp placed in a 12-inch RLM Standard Dome porcelain enameled steel reflector. If it is desired to light the side benches, 25-watt lamps should be used and mounted 2 feet above the center of the bench and spaced on 3-foot centers. The same type of equipment—namely, the RLM Standard Dome—is suggested.

18-FOOT GREENHOUSE

For the 18-foot greenhouse it is suggested that a single row of outlets be located on the center line and mounted 6 feet above the bench. These units may be spaced on 9-foot centers and equipped with 150-watt, inside-frosted or white-bowl Mazda lamps placed in 14-inch RLM Standard Dome porcelain enameled steel reflectors. For lighting the side benches it is suggested that 40-watt lamps be located over the center of the bench and installed 2 feet 8 inches above the center of the bench on 4-foot centers.

26-FOOT GREENHOUSE

For lighting this greenhouse it is suggested that two rows of outlets be used and located 5¼ feet from the center line, or with a spacing of 10½ feet between rows. These units should be mounted 5 feet above the bench and located on 7½-foot centers; 100-watt, inside-frosted Mazda lamps equipped with 12-inch RLM Standard Dome porcelain enameled steel reflectors will provide satisfactory illumination. For lighting the side benches it is again suggested that the 40-watt lamps be located 2 feet 8 inches above the center of the bench and spaced approximately 4 feet apart.

37-FOOT GREENHOUSE

It is suggested for lighting this greenhouse that three rows of units be used and the rows spaced 10 feet apart, the center row being located on the center line of the greenhouse and mounted 11 feet above the bench. These units should utilize the 300-watt, inside-frosted or white-bowl Mazda lamps equipped with 18-inch RLM Standard Dome porcelain enameled steel reflectors, spaced approximately 9 feet apart. For the side rows the units should be mounted 5½ feet above the bench and spaced 9 feet apart. These units should be equipped with 150-watt RLM Standard Dome porcelain enameled steel reflectors. Since the side benches are 3 feet wide, 25-watt Mazda lamps should be installed on 3-foot centers and mounted 2 feet above the benches.

44-FOOT GREENHOUSE

It is suggested that three rows of outlets be installed 12½ feet apart, the center row again being placed on the center line of the greenhouse, and the units mounted 12 feet above the bench top and spaced 11 feet apart. Three-hundred-watt, inside-frosted or white-bowl Mazda lamps should be used and equipped with 18-inch RLM Standard Dome porcelain enameled steel reflectors. The two side rows should be mounted approximately 6 feet 8 inches above the top of the benches and spaced 11 feet apart. Two-hundred-watt, inside-

frosted or white-bowl Mazda lamps, equipped with 16-inch RLM Standard Dome porcelain enameled steel reflectors, will provide satisfactory illumination. The three benches along the side walls may be similarly lighted by 25-watt lamps located on 3-foot centers and mounted 2 feet above the center of the bench.

Table 29 gives the sizes of lamps and spacing which will be necessary to provide reasonably uniform illumination of 10 foot-candles over individual benches of various widths.

TABLE 29.—Illumination of Individual Benches

Bench width	Mounting height—bottom of reflector above bench	Spacing	Lamp size
Ft.		*Ft.*	*Watt*
3	2 ft.	3	25
4	2 ft. 8 in.	4	40
5	3 ft. 4 in.	5	50
6	4 ft.	6	75

Table 29 will provide an average of approximately 10 foot-candles of illumination with maximum and minimum values of approximately 15 and 5 foot-candles, respectively.

Table 30 gives the spacing and mounting height, together with the area in square feet which may be lighted to an average value of approximately 10 foot-candles with maximum and minimum values of approximately 15 and 5 foot-candles for the various size lamps.

TABLE 30.—Illumination of Area in Square Feet

Lamp size	Mounting height—bottom of reflector above bench	Spacing	Area in square feet
Watt		*Ft.*	
25	2 ft.	3	9
40	2 ft. 8 in.	4	16
60	3 ft. 4 in.	5	25
75	4 ft.	6	36
100	4 ft. 8 in.	7	49
150	6 ft.	9	81
200	6 ft. 8 in.	10	100
300	10 ft.	15	225
500	13 ft. 4 in.	20	400
750	16 ft. 8 in.	25	625
1000	20 ft.	30	900

CORRECT VOLTAGE

Another factor which is sometimes overlooked by greenhouse forcers is the importance of using lamps of the same voltage or a little lower than the voltage of their lighting circuit. If lamps of higher voltage than the circuit are used, the amount of light they will deliver falls off rapidly, much more rapidly than the reduction of wattage consumed, so that the net result is an increase in the cost per lumen of light. If lower total cost is desired, it is far better to use lower wattage lamps burned at their rated voltage than to burn lamps under voltage. Furthermore, burning lamps under voltage changes the spectral character of the light, unduly increasing the percentage of the red to the possible detriment of the plants.

WIRING

In making any lighting installation great care should be used to install wire which is large enough; i. e., which has sufficient capacity to carry the full lamp load. Table 31 gives an approximation of the wire sizes that should be used between the panel box and the lamps for various wattages.

The difference in the cost of wiring with No. 12 instead of No. 14 wire is so slight and the advantages generally sufficient that many electrical men specify No. 12 as the minimum size for branch circuits.

This table shows the wire size required for 115-volt circuits of various lengths of run, based on a drop of 2 volts between the panel board and the outlets.

It is difficult in branch circuits, at least with present wiring methods, to use larger than No. 8 wire because of the difficulty of handling in conduit. Where the proper wire size for a proposed installation, according to this table, is larger than No. 8, it is usually best either to provide more circuits with less load or to relocate distribution centers to decrease lengths of run.

It is more or less common practice to use ordinary flexible lamp cord for drop lights in greenhouses. This is satisfactory for drops of the usual length—i. e., not exceeding 10 feet—provided not more than 300 watts are used on each drop. Lamp cord should by no means be used for the main line from which the individual drops are run.

CLEANING

Another point that is often overlooked is the cleaning of lamps and reflectors. It is surprising how much light is absorbed by dirt and dust. It is not unusual to find conditions where the light has been decreased as much as 20 or 30 per cent simply because the equipment has not been kept clean. Porcelain enamel reflectors do not collect dirt as readily as those with painted surfaces and they are easier to clean. Wiping out with a dry cloth about once a month should keep them in pretty good condition under ordinary circumstances.

ADDITIONAL LIGHT FOR HOUSE PLANTS

In view of the results secured with the use of additional light for flowering greenhouse plants, tests were undertaken to determine the feasibility of prolonging the life of plants in the home where light intensities are low. Through the cooperation of the General Electric Company of Cleveland equipment was secured, consisting of iron plant stands with five holders each. The source of illumination was provided from above with lamps of varying wattage placed in reflectors and parchment shades.

Four different tests were run and replicated a number of times. They were as follows:

1. Influence of light intensity
2. Influence of light duration
3. Distance from light source
4. Effect of light on variety of plants

The lamps used were 60-watt, 100-watt (daylight), 100-watt (frosted), and 200-watt. The most satisfactory was the 100-watt frosted lamp. From the study of the varying duration of illumination periods, it was found necessary to use additional light for 5 hours from dusk on, and in dark rooms the additional illumination was required for 10 hours per day.

TABLE 31.—Wire Size Required*

(Length of wire for a circuit is double the length of run)

Length of Run (Panel box to outlet)	Watts per circuit																					
	100	150	200	300	400	500	600	700	800	900	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200
30	14	14	14	14	14	14	14	14	14	14	14	14	14	12	12	12	12	10	10	10	10	10
40	14	14	14	14	14	14	14	14	14	14	14	12	12	12	10	10	10	10	10	8	8	8
50	14	14	14	14	14	14	14	14	14	12	12	12	12	10	10	10	10	8	8	8	8	8
60	14	14	14	14	14	14	14	14	12	12	12	10	10	10	10	8	8	8	8	8	6	6
70	14	14	14	14	14	14	14	12	12	12	12	10	10	8	8	8	8	8	6	6	6	6
80	14	14	14	14	14	14	12	12	12	10	10	10	8	8	8	8	8	6	6	6	6	6
90	14	14	14	14	14	12	12	12	10	10	10	10	8	8	8	6	6	6	6	6	6	4
100	14	14	14	14	14	12	12	12	10	10	10	8	8	8	6	6	6	6	6	6	4	4
110	14	14	14	14	14	12	12	10	10	10	10	8	8	8	6	6	6	6	4	4	4	4
120	14	14	14	14	12	12	10	10	10	8	8	8	8	6	6	6	6	4	4	4	4	4
130	14	14	14	14	12	12	10	10	10	8	8	8	6	6	6	6	4	4	4	4	4	4
140	14	14	14	14	12	12	10	10	8	8	8	8	6	6	6	6	4	4	4	4	4	4
150	14	14	14	12	12	10	10	10	8	8	8	6	6	6	6	4	4	4	4	4	4	2
160	14	14	14	12	12	10	10	8	8	8	8	6	6	6	4	4	4	4	4	4	2	2
170	14	14	14	12	12	10	10	8	8	8	8	6	6	6	4	4	4	4	4	2	2	2
180	14	14	14	12	10	10	10	8	8	8	6	6	6	6	4	4	4	4	4	2	2	2
190	14	14	14	12	10	10	8	8	8	6	6	6	6	6	4	4	4	4	4	2	2	2
200	14	14	14	12	10	10	8	8	8	6	6	6	6	6	4	4	4	4	4	2	2	2
210	14	14	14	12	10	10	8	8	8	6	6	6	6	6	4	4	4	4	4	2	2	2
220	14	14	14	12	10	10	8	8	8	6	6	6	6	6	4	4	4	4	4	2	2	2
230	14	14	12	12	10	8	8	8	6	6	6	6	6	4	4	4	4	4	2	2	2	1
240	14	14	12	10	10	8	8	8	6	6	6	4	4	4	4	2	2	2	2	2	1	1
250	14	14	12	10	10	8	8	8	6	6	6	4	4	4	4	2	2	2	2	2	1	1

Note: These recommendations on wiring are based on the allowances of The National Code—i. e., circuits equipped with medium screw sockets limited to 15 amperes and not more than 12 outlets per circuit; mogul sockets—limited to 40 amperes and eight outlets per circuit. Present wiring practice is usually well within the limit allowed by the code. In some cases it is necessary to meet other requirements of local codes.

The following plants showed definite prolongation of flowering and life through the use of additional light:

Asparagus sprengeri	Geranium
Begonia semperflorens	Kalanchoe
Boston fern	Saintpaulia

On the other hand, such flowering plants as Cineraria, Cyclamen, and Marigold showed no beneficial effects. The same was true of *Crassula arborescens, Hedera helix, Pandanus veitchei, Pepperomia cordata, Sansevieria zeylanica,* and *Begonia Rex.*

EFFECT OF ARTIFICIAL LIGHT ON GROWTH OF HOUSE PLANTS WITHOUT NATURAL LIGHT

During 1934-1935 a commercial test of growing house plants in rooms where no sunlight was available was conducted. On September 29 seven lamp fixtures were placed about the lobby of the Neil House, Columbus, Ohio. Notes on the growth and condition of the plants were taken at varying intervals. The lamps used varied. A 40-watt lamp was used in a fixture holding one plant, while 150-watt lamps were used in fixtures made to display five plants. These lamps were allowed to run for a period of 19 hours, from 7 A. M. until the following 2 A. M.

TABLE 32.—Effect of Artificial Light on Growth of House Plants

Plant	Period plants remained in good condition	Rating
	Mo.	
Acuba japonica	8	Excellent
Aloe denticulata	4	Good
Anthericum liliastrum	4	Fair
Asparagus sprengeri	2	Poor
Cissus rhombifolia	4	Fair
Crassula arborescens	8	Excellent
Crassula lycopodiodes	4	Good
Crassula pseudo-lycopodiodes	4	Good
Crassula tetragona	4	Good
Cyrtomium falcatum	1	Poor
Dieffenbachia braziliensis	4	Good
Dracaena fragrans massangeana	8	Excellent
Dracaena terminalis	3	Fair
Ficus elastica	4	Good
Hedera helix	6	Good
Nephrolepis exaltata bostonensis	5	Fair
Pandanus veitchei	8	Excellent
Pepperomia cordata	4	Good
Portulacaria afra	6	Excellent
Sansevieria zeylanica	8	Excellent
Saxifraga sarmentosa	1	Poor

Plants such as *Saxifraga sarmentosa* and *Asparagus sprengeri* did not respond to artificial light conditions as well as the other foliage plants. The other foliage plants made growth and remained in form.

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